THURSDAY, MARCH 19, 1885

THE DEBATE ON VIVISECTION AT OXFORD

IN our last issue we gave a brief notice of the proceedings in an overflowing Convocation at Oxford, which resulted in a majority of 412 votes to 244 in favour of the decree promulgated by the Hebdomadal Council. This decree had only an indirect bearing upon the question of vivisection; but as it was made an occasion for a fresh, and, let us hope, a final trial of strength between the scientific and anti-scientific forces of the University, it is desirable to furnish our readers with a somewhat more full account of what took place than we had time to print last week. Seeing that the debate had clearly been organised with no small amount of care on the side of the anti-vivisectionists, and that the ablest as well as the most authoritative speakers in Oxford who could support their cause were put forward, we may regard the arguments which were adduced as a fair example of the best that can be said against vivisection by cultured thought and cultured speech. We will therefore confine our remarks to what was said on this side of the question.

Regarded as a piece of oratory, the speech of Canon Liddon was, in our opinion, perfect; and the effect of what we may term an artistic eloquence was enhanced by the appearance and costume of the speaker, as well as by the appropriateness of his surroundings in the densely crowded Sheldonian Theatre. But when we look from the manner to the matter of his speech, we are unable to bestow such unqualified praise, although we confess that even here we were agreeably surprised by the judicious moderation of its tone. His views, briefly stated, were that so long as we hold it morally lawful to kill animals for food, or otherwise to use them for our own purposes, so long must we in consistency hold that, under certain circumstances, it is morally lawful to inflict pain upon animals for the benefit of man: the special case of vivisection does not differ in principle from other cases where pain is thus inflicted; but it ought to be qualified by three conditions—it should be resorted to as rarely as possible, it should be guarded against the instinct of cruelty, and it should be so used as not to demoralise spectators. With all this every physiologist would of course agree. The Canon, however, proceeded to talk what in the strictest meaning of the word must be termed nonsense, when he affirmed that physiology might be "divorced" from vivisection. That this statement has gained currency among the anti-vivisectionists does not alter its essentially unreasonable character. It is perfectly true that in many departments of physiological research vivisection is not required; but it is no less true that in many other departments vivisection is an unconditional necessity. This fact, one would think, admits of being rendered obvious to any impartial mind, howsoever ignorant of physiological science. For if this science consists in the study of vital processes going on in the living organism, does it not obviously follow that some of them can only be studied while actually taking place? How, for example, would it be possible to gain any knowledge of the electrical and other changes which occur in a gland during the process of secretion, except by estimating these changes during the act of secretion? The gratuitous information which physiologists receive from technically ignorant sources touching the nature and the value of their own methods, can only suggest the presumption of inexperienced youth when venturing to instruct a maternal grand-parent in the practical aspects of oology.

It appears that Prof. Burdon-Sanderson had pledged himself not to exhibit vivisections to his class for the purposes of teaching, and for this concession to the unreasoning prejudice of his opponents he received a warm expression of gratitude from Canon Liddon. Probably enough, under the circumstances in which he is placed, the concession is a prudent one; but that it merited the eulogium which was bestowed upon it by Canon Liddon on moral grounds, no man of common sense could very well suppose. Demonstrations on the living subject, if performed in a class-room at Oxford, would of course be always performed on animals under the influence of anæsthetics; and therefore the "demoralising" effects upon the minds of young men, which Canon Liddon takes to have been averted by Prof. Sanderson's concession, can only be understood to consist in disregarding the mawkish sentimentality which cannot stand the sight of a painless dissection. This kind of "morality" may be regarded as tolerable in a girl: in a man it is not tolerable, and deserves the same kind of pitying contempt as is accorded to personal cowardice, with which it is most nearly allied.

Canon Liddon, however, regretted that Prof. Sanderson had not further pledged himself to restrict his experiments *for the purposes of research* to animals kept under the influence of anæsthetics during the operations, and killed before recovering from their anæsthesia. We have no doubt that Prof. Sanderson might have complied with the first of these suggestions without any serious detriment to his future researches. For, as a matter of fact, the cases in which anæsthetics interfere with the progress of an experiment are, comparatively speaking, very rare indeed, except where the occurrence of pain forms a necessary part of the experiment—*i.e.* in certain researches on the functions of sensory nerves. But as all the functions of sensory nerves which require for their study the infliction of pain have already been worked out, physiology as it now stands does not demand the absence of anæsthetics, save in a very small per centage of operations. Therefore, when pain is inflicted during an operation, it is due, as a rule, not to the exigencies of research, but to the indifference of the operator—a fact which we think physiologists ought to be more insistant than they are in impressing upon the mind of the public. Nevertheless, we feel persuaded that Prof. Sanderson was perfectly right in not binding himself never to operate without anæsthetics; for by so doing he would have virtually conceded the principle that the suffering of an animal is too great a price at which to buy an advance of knowledge; and this, among other things, would have been to place a moral stigma upon some of the most valuable researches of the past. Besides, as was pointed out in the course of an able speech by Prof. Dicey, it is not desirable that the *status* of a Professor in the University should be regarded as beneath that of a gentleman; and if it is supposed that Dr. Sanderson is not to

be trusted in the latter capacity, he ought never to have been chosen to fill an Oxford chair. In short, as the representative of physiology in Oxford, Dr. Sanderson, by the nature and extent of his concession, has drawn a clear distinction between the importance of teaching and of research: he has consented to allow the teaching to suffer if needs be; but he will not consent to yield an inch where the principles of research are concerned.

The other suggestion which was thrown out by Canon Liddon—namely, that a Professor of Physiology ought to pledge himself to kill every animal before it recovers from its anæsthesia—is, from every point of view, absurd. In the first place, the suggestion can only emanate from the uninformed supposition that the pain of a healing wound is considerable. But we know from the experience of hospital practice that even the most severe wounds are painless while healing, unless the process of healing is complicated by morbid conditions, which now admit of being wholly prevented by antiseptic methods. As a matter of fact, therefore, in our physiological laboratories, as in our surgical wards, there is at the present time but an extremely small amount of suffering to be found in connection with the healing of wounds; and no man of ordinary sense who had ever seen the inside of either the one or the other would have cared to make the suggestion which we are considering. But, in the next place, even if this were not so, it would have been highly wrong in any Professor of Physiology to restrict himself to the performance of experiments the objects of which could be secured during the action of an anæsthetic. Certainly more than half the experiments which the physiologist has now to perform have reference to questions of after-effects, and this is especially the case in experiments bearing upon the problems of pathology.

The speech of the Bishop of Oxford was bad, both in logic and in taste. It was bad in logic because in arguing for the total suppression of physiological research in Oxford, he relied upon foreign practice for his evidence of cruelty. This was essentially illogical, because it fails to distinguish between two very different things—namely, the cruelty, if any, which attaches to vivisection *per se*, and the cruelty which arises from other sources. If the state of public feeling in some foreign countries is not so sensitive as it is in our own on the matter of inflicting pain upon the lower animals, it is obviously unfair to search through the Continent for instances of cruelty in connection with physiological research, and then to adduce such instances as proof of cruelty necessarily attaching to physiological research at home. We might as well argue against the use of mules in England because these animals are badly treated in Spain. As we have already said, there are now but extremely few cases possible in which the occurrence of pain is necessary for the purposes of an experiment; and therefore the proof of pain having been inflicted in any one case constitutes proof, not of the pain-giving character of vivisection in general, but of the carelessness of some operator in particular. The cruelty must belong to the individual, not to the methods; and we are not aware that any charge of cruelty has hitherto been proved against an English physiologist.

The Bishop of Oxford's speech was bad in taste, because he sought, missionary-wise, to tell some anecdote of horror, which the good sense of Convocation prevented him from narrating further than that the subject of his story was to have been "an affectionate little dog." But, as he was not able to give any reference to the scene of his tragedy, after a prolonged battle with his audience upon this somewhat necessary proof of authenticity, he was obliged to give way. His taste was perhaps still more questionable when, in the presence of Prof. Sanderson and other working physiologists, he proceeded to adduce the favourite argument that the pursuit of experimental physiology exercises a baleful influence on the moral nature. That the argument is unsound, both in principle and in fact, we need not wait to show.

The speech of Prof. Freeman was rendered wholly inaudible by a general uproar, which proceeded chiefly from the side which he rose to support. We were told that this was due to the memory of the effect which was produced by his speech on the occasion of the previous vote.

Upon the whole we think that the debate was of no little service to the cause of physiology in Oxford; and when we consider how largely the majority of votes has grown since the first of the three divisions, we are glad to congratulate the University upon having shown so emphatically that, not less than her sister, she is able to withstand the assaults of the two great enemies of learning—Ignorance and Fanaticism.

THE RELATIVE EFFICIENCY OF WARSHIPS

IN our last week's issue we published a letter from Sir Edward Reed adverting to some points in an article which appeared in our number of February 26 upon "The Relative Efficiency of War Ships." In order to show the difference existing between the ships of the *Inflexible* or *Agamemnon* class and those of the *Admiral* class, as regards height of armour above the water, we then gave profiles of the *Agamemnon* and of the *Collingwood* (one of the *Admiral* class). We now give outline sections of the same vessels, in which this large difference can be more clearly seen, and by means of which its importance can be better understood.

Before giving any figures in connection with this question it may be as well to mention another point which, taken alone, is not unworthy of notice. We refer to the difference between the *Agamemnon* and *Collingwood* with regard to depth of armour below the water. When the *Agamemnon* is floating in smooth water, with her unarmoured ends uninjured, the depth of her armour below the water-line is 5 feet 10 inches, whereas that of the *Collingwood*, under the same conditions, is only 5 feet, as shown in Figs. 1 and 2 respectively. This difference of nearly 1 foot is of some importance, because every two or three inches gained in depth of armour below the water means a large increase in the safety of the ship when fighting at sea. When the ends of the *Agamemnon* are flooded she sinks 22 inches deeper in the water, and the depth of her armour below its surface would, therefore, then be 7 feet 8 inches (Fig. 3). The *Collingwood*, when her ends are flooded, sinks 17½ inches deeper in the water, and in that condition, therefore, her armour would be 6 feet 5½ inches below the water's surface (Fig. 4), or 1 foot 2½ inches less than that of the *Agamemnon*. In the earlier ironclads it was considered necessary to carry

the armour to a depth of at least 6 feet below the normal water-line, and as much deeper as individual cases would allow. It is evident, therefore, that the ships of the *Admiral* class are deficient in this respect unless and until their unarmoured ends are flooded.

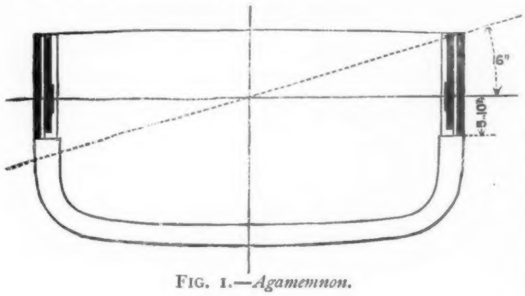

FIG. 1.—*Agamemnon.*

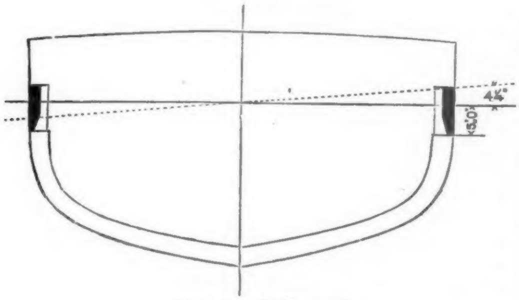

FIG. 2.—*Collingwood.*

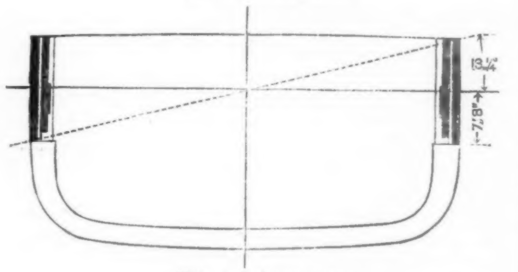

FIG. 3.—*Agamemnon.*

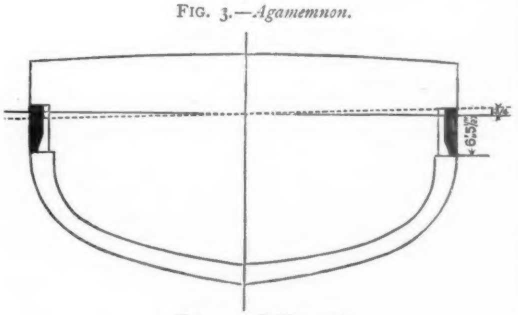

FIG. 4.—*Collingwood.*

Reverting to the still more important question of height of armoured freeboard (*i.e.* the height of the top edge of armour at side above the water), we will now give some figures. The *Agamemnon*, with her armoured freeboard of 9 feet 6 inches in the uninjured condition, can be inclined to the angle of 16 degrees before the top edge of her armour touches the water, as shown by the dotted line in Fig. 1; and even when her unarmoured ends are flooded, and her freeboard therefore reduced to 7 feet 8 inches, she can still be inclined (assuming for the moment that she would still have stability) to the angle of $13\frac{1}{4}$ degrees before her armour is brought beneath the water: this is shown in Fig. 3. But the *Collingwood* has so ridiculously shallow a partial belt (only 2 feet 6 inches above the water in the uninjured condition) that an inclination of only $4\frac{1}{4}$ degrees causes her armour to disappear altogether in smooth water. When her ends are flooded her armoured freeboard is actually reduced to no more than $12\frac{1}{2}$ inches, which is as much as to say that at sea she would have no armoured freeboard at all in that condition, for an inclination of but $1\frac{3}{4}$ degrees is sufficient to bury her armour completely, even in smooth water. The two conditions of the *Collingwood* are shown in Fig. 2 and Fig. 4 respectively.

These alarming facts, thus clearly brought into view are of themselves sufficient to explain Sir Edward Reed's distrust of the *Admiral* class of ship, and his very strong condemnation of these ships can be readily understood when we remember, further, that in his opinion the excessive shortening of the armoured part in the whole of these ships has introduced such elements of danger into them as to render them unfit to take their place in the line of battle, even apart from the considerations previously set forth.

THE AMERICAN ASSOCIATION

Proceedings of the American Association for the Advancement of Science (Thirty-Second Meeting), held at Minneapolis, Minn., August, 1883. (Salem: Published by the Permanent Secretary, 1884.)

THE record of the proceedings of the thirty-second meeting of the American Association forms a volume considerably less bulky than that issued by the British Association, as it consists of 598 pages, the corresponding volume of the older Association numbering 884 pages. The difference between the two volumes, as records of science, is about in the same proportion. Addresses, reports, and abstracts of papers take up 468 pages in the book before us, while in the Southport volume the same subjects occupy 660 pages. In printing and paper the American volume is decidedly the superior of the British, but, as a set-off, it is issued in a paper cover; the price, however, is only 1·50 dollars. The smaller size of the volume is accounted for by the fact that considerably fewer papers appear to have been read before the American Association than before the British. We note also another point of difference, certainly not to the advantage of the American volume: the reports on the state of science, so conspicuous and valuable a feature in the British volume, are remarkable in the American chiefly by their absence. We venture to suggest to the officers and Committee of the latter Association that they would add largely to its importance and stability by developing this branch of its work. At the present time, when scientific societies for special purposes are so numerous, their meetings and journals will always compete successfully with those of an all-embracing Association such as the British and others formed on a similar plan'

for original papers of real importance; but the task of recording progress, of acting as the historians of science, is rightly declined by societies which aim at advance rather than at retrospect. Hence this most important function can be best discharged by these great Associations, and it will always suffice to save them from degenerating into scientific camp-meetings or picnics.

The Sections in the American Association are equally numerous with those in the British at the present time, though differently arranged. Mathematics and Physics are divided, Geology and Geography united; Histology and Microscopy form a section separate from Biology. We doubt the advantages of the union in the second case, and of the separation in the third. That no address is printed in this volume, and that the only record of the proceedings of the Section of Histology and Microscopy is the statement that, although some meetings took place, no papers were read before it, seems an indication that, as in Britain, its subjects might safely be merged in Biology, the latter Section having the power of temporary subdivision.

In another respect too the American differs from the British Association. In the latter the delivery of an address is the first official act of its President, in the former it is the last. The address at Minneapolis was delivered by Principal (now Sir William) Dawson, and is characterised by the scientific caution and literary ability of its author. It gives a critical sketch of the results of geology, more especially with reference to the development of the earlier rocks and to the evolution of living creatures. In regard to the former, Sir W. Dawson inclines to drawing a marked line of separation between the Lower Laurentian or Ottawa gneiss of Sir W. Logan and the Middle Laurentian or the Grenville series of the same, which is characterised by beds of limestone and dolomite, "quartzite, quartzose gneisses, and even pebble beds," besides graphite, iron ore, and the debatable *eozoon*, which Sir W. Dawson considers as indicating the existence of land surfaces of the fundamental gneiss. The Upper Laurentian or Norian series is noticed with due caution, though it is regarded as decidedly younger than the preceding formation. The Huronian, Montalban, and Taconian (Lower Taconic of Emmons) are next mentioned, but the author, though inclining to the views of Dr. Sterry Hunt as to their order of succession, forbears to dogmatise as to their precise relations either mutually or with "certain doubtful deposits around Lake Superior." With regard to the development of life, he is decidedly adverse to the evolution school among biologists, but is not able to add anything material to the familiar arguments of its opponents. The address concludes with a brief notice of some of the obscure markings, variously referred by palæontologists to algæ, protozoa, and tracks of various animals, and with a critical sketch of the theories relating to the Glacial Epoch, in which he expresses himself as opposed to the extreme views of the former extension of land-ice and its erosive action which are favoured by some geologists.

Two other papers are given as "read in General Sessions," which we presume may be regarded as in some respect analogous with the evening discourses at the British meetings. The one by Dr. Sterry Hunt, "On a Classification of the Natural Sciences," is printed in abstract only; the other, by Prof. E. D. Cope, entitled "The Evidence for Evolution in the History of the Extinct Mammalia," is an extremely able and temperate sketch of the views antagonistic to those entertained by the retiring President. "The German Survey of the Northern Heavens" forms the subject of an interesting address by Prof. W. A. Rogers, who presided over the section of Mathematics and Astronomy, and Prof. H. A. Rowland delivered a "Plea for Pure Science" to the section of Physics. Both these sections received a considerable number of communications. The section of Chemistry does not appear to have had a special address, and the number of papers read before it was not large. The same may be said of the Mechanical Section, in which only seven papers are recorded as read. Prof. Hitchcock, in the section of Geology and Geography, took the "Early History of the North American Continent" as the subject of his address, in which he favours the idea that the bulk of the early crystalline rocks are of igneous origin, being metamorphosed volcanic rocks or tuffs. Ice and its leavings form the subject of a large proportion of the papers read before this section. More than one of these is of much interest, especially that by Mr. W. Upham on the Minnesota Valley in the Ice Age. Messrs. H. C. Bolton and A. A. Julien describe "The Singing Beach of Manchester, Mass.," noticing in the course of the paper the sonorous sand in the Island of Eigg (Hebrides), as well as others on record. It results from their observations that the sound is due to the grains, which are not rounded, but have flat and angular surfaces. It is, we think, undoubtedly a vibration phenomenon. We are acquainted (probably the fact is common) with a small screw-tap in a lavatory, which is loudly sonorous when a certain amount of water is allowed to issue, but silent in other positions. Prof. W. J. Beal, in addressing the Section of Biology, deals with "Agriculture, its Needs and Opportunities;" and the Section received a considerable number of interesting communications. Dr. Franklin B. Hough addressed the Economic Section on the method of statistics, and the address of Mr. E. B. Elliott, delivered to the same Section at the preceding Montreal meeting, is printed in this volume. This Section does not appear to receive nearly so many communications as the corresponding one of the British Association. The address of Prof. O. T. Mason to the Section of Anthropology deals with the scope and value of anthropological studies, and a considerable number of interesting papers were read. Those relating to mound-building may be of service to European archæologists as offering suggestions which may help in the interpretation of some of the earthworks in the Old World.

LETTERS TO THE EDITOR

The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.

[The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to insure the appearance even of communications containing interesting and novel facts.]

On the Terminology of the Mathematical Theory of Elasticity

THE late Dr. Todhunter left, in an incomplete state, a valuable "History of the Mathematical Theories of Elasticity,"

which the syndics of the Cambridge University Press have intrusted to me to complete and edit. In reading the great number of memoirs relating to the subject I have been much struck by the want of a clear and accurate terminology in both theoretical and practical elasticity. I have been forced to the conclusion that the great discrepancy, which is often to be found between theoretical and practical results, is in some measure due to the want of this terminology (*e.g.* the extreme looseness of the term "limit of elasticity"). I find it needful for the purposes of the above work to adopt such a terminology, but before doing so it would be extremely valuable to have the opinion of some of our leading elasticians on the terms I venture to propose. I should be very glad of any suggestions, through the columns of NATURE, towards a definite and uniform terminology.

I am particularly dissatisfied with the term "limit of superimposition." It is exceedingly clumsy. Other possible terms are—"limit of superposable stress," "linear limit," and "limit of constant slope," the last two phrases having reference to the fact that the stress-strain curve at this limit ceases to be a straight line. With regard to this limit of superimposition I may remark that it may arise from one of two causes—(1) The strain components become so large that we cannot neglect the squares of small quantities, or the stress components can no longer be taken proportional to those of strain. This might happen before permanent set. (2) Permanent set may arise which does not follow the generalised Hooke's Law. This seems the more probable case, and has been adopted below. Prof. Kennedy tells me that he thinks when a body has been reduced to a state of ease that the superior elastic limit and the limit of superimposition coincide.

It has been proposed, I believe, to term that limit of stress at which bars begin locally to "thin down" the limit of viscosity. The "limit of uniform strain" is not altogether satisfactory or quite suggestive of this peculiar viscosity. "State of maximum stress" might perhaps serve the purpose, were one quite sure that this state always coincides with the viscous limit.

In the following remarks I have been much assisted by Prof. J. Thomson's epoch-making paper in the *Cambridge and Dublin Mathematical Journal* for 1848, and even more by Prof. Alex. B. W. Kennedy's paper on Riveted Joints in the *Proceedings* of the Institution of Mechanical Engineers, April, 1881 (especially pp. 208-213).

We have first to distinguish between two classes of materials. In the one we may suppose the particles to be in a state of internal stress before any external force is applied; in this case any, the least, external stress will probably produce permanent set. If this stress be removed and then reapplied, after one or two trials it will cease to produce permanent set, or at least the permanent set will be extremely small as compared with the elastic strain. We thus need a term to mark that state of the body when external stress does not produce permanent set owing to the existence of internal stress. This might perhaps be termed the *state of ease*. Many discordant results with regard to the constants of elasticity are not improbably due to the fact that the ratio of stress to strain has been measured before the material has been reduced to a *state of ease*. In the second class of materials we may suppose this state of ease to exist before the application of any stress. Supposing a body to be in its state of ease, there will then exist two limits, one on one side, and one on the other of the unstrained shape, which may be termed the *inferior and the superior limits of perfect elasticity*. Any external stress which does not produce a strain exceeding these limits will not give rise to permanent set. These inferior and superior limits of perfect elasticity mark, as a rule, the range covered by the usual mathematical theory. Within these limits it is generally safe to assume that the components of internal stress are proportional to the components of strain. In some cases, *i.e.* cast iron, where, however, it is difficult to produce the state of ease, this does not seem to be accurate—the stress and strain components appear never to be proportional.

In most materials the range of perfect elasticity is not large. An external stress, which is by no means nearly equal to that which is required to produce rupture will give rise to a permanent set. Thus permanent set in some materials will commence at a stress only $\frac{1}{3}$ to $\frac{1}{4}$ of the stress that those materials are capable of standing. Thus beyond the limit of elasticity we have first a range of stresses, which produce strains partly elastic and partly permanent. The strain in this range might still remain proportional to the stress; the permanent is yet small as compared with the elastic part of the strain. This range is bounded, however, by a stress for which the strain ceases to be proportional to the stress. In other words, the "generalised" Hooke's law is no longer applicable. Up to this point, if we are merely desirous of finding the strain produced by any system of statical stress, the mathematical equations of elasticity will apply, supposing, as seems probable, that the elastic constants do not alter, owing to the permanent set. Those equations would not of course be valid if we wished to find the strain in the body, if the stress were altered, nor would they suffice to treat vibratory motions capable of producing permanent set. This limit, which is that at which the *ut tensio sic vis* principle ceases, requires a name. It might perhaps be termed the *limit of superimposition*. That is to say, if a certain addition to this limiting stress produced a certain increase of strain, and a second addition another increase, these increments of stress, if superimposed would not produce the sum of the strain increments. It might at first sight appear more direct to term it the modular limit, or the limit of Hooke's law, but it would seem that, after this limit is passed, Hooke's law, probably with the same modulus, applies to so much of the strain as is elastic strain; in fact at the limit of superimposition it is the permanent set part of the strain which ceases to obey Hooke's law. In some materials the limits of perfect elasticity and of superimposition may coincide. At the latter limit the permanent set is still in some cases only one-twenty-fifth of the total strain. Neither of the limits above considered is *commercially* treated as the limit of elasticity. This is the point at which the material "breaks down," that is to say, the stress being continually increased, a strain is obtained which would be preserved by replacing the stress by one very much less. The material is unable to balance the stress upon it. If the stress be maintained the strain will suddenly increase by a considerable amount (without the stress being increased). This remarkable limit, it has been suggested by Mr. Tweddell, should be termed the *limit of fatigue*. The limit of fatigue being past, a small proportion of the strain, namely, so much as corresponds to the modulus, is elastic, the greater part is permanent set.

In the case of bars of iron subjected to longitudinal pull, if the stress be increased beyond the limit of fatigue, another limiting strain is reached, namely, one at which local contraction begins, or the bar commences to draw out at some point, *i.e.* the strain ceases to be uniform. The material now begins to act as if it were "viscous," and it would be convenient to describe this state as that of *viscosity*, had not this name been appropriated to that permanent set which may be produced by the application for a long period of a stress well within the limits of perfect elasticity. Closely associated, if not the same, with this *limit of uniform strain* is the state of maximum load. From this point onwards, as the strain increases the load decreases, till the breaking load is reached with a magnitude below that of the maximum load. To distinguish one from the other requires a special manipulation. As a rule, what is meant by the *absolute or breaking strength* is probably the *maximum load*, for if this load was allowed to remain, the bar would break under it. It might perhaps be convenient, however, to speak of one as the *maximum* and the other as the *terminal load*. With the terminal load the "elastic life" of the material is concluded. It must be remembered that owing to the bar locally thinning down, the stress per unit area at the terminal load is greater than the stress per unit area at the maximum load.

Such are the limits for which it is needful that a terminology should be established. I shall be extremely glad if any of the readers of NATURE, who happen to be elasticians, will suggest a more concise phraseology. KARL PEARSON

University College, February 14

Civilisation and Eyesight

I HAVE been interested in Lord Rayleigh's note on "Vision," and would offer my mite on the subject.

I have no doubt that brilliancy of image and power of distinguishing largely depend on definition. The brilliancy does so for the same reason as that which induces an artist to heighten colour-effects by sharp contrasts. In the same way, if we seek to decide if two colours are alike, we place them in immediate contact with a sharp edge. Details are best seen with a telescope when the images are sharp and untroubled. When slight tremors are in the air, and the image is rapidly displaced in all directions, so that what we see is the resultant

of many rapidly succeeding impressions, then tints are graded into one another at the edges, and we lose the power of distinguishing detail.

I can give, fortunately, a case in point. My eyes are affected with a small amount of astigmatism. It does not affect general vision for ordinary purposes, nor, of course, the definition of single lines; but, when I use appropriate lenses, the whole scene becomes brighter and more cheerful, and I see details. The bark of a tree is a perfectly different object with and without them. With them it is like a good photograph; without them, like many pictures. Formerly, in addition to the cylindrical surface, I required a slight spherical concave, and I was disposed to place the increased general brilliancy of the view mainly to the reduction of size, but I now use plano-cylindrical lenses for distant vision, and it is evident that the brilliancy is solely due to the better definition.

I would, lastly, suggest for Lord Rayleigh's consideration the question whether the change of focus of his eyes in faint light is not partly, at all events, due to change in the colour of the light. I know that there is such a change with me, but I have long had reason to believe that colour affects my vision.

J. F. TENNANT

37, Hamilton Road, Ealing, W., February 7

THOSE who have compared Lord Rayleigh's letter in NATURE of February 12 with that of Mr. Brudenell Carter on February 26 will have observed an inconsistency occasioned by a slip of the pen.

The latter says: "The commonly accepted standard of normal vision is satisfied by deciphering letters the parts of which subtend visual angles of one minute. . . ." Also, Prof. McKendrick states that "The smallest visual angle in which two distinct points may be observed is 60 seconds."

According to Lord Rayleigh, however, "A double star cannot be fairly resolved unless its components subtend an angle exceeding that subtended by the wave-length of light at a distance equal to the aperture. If we take the aperture of the eye as 1/5th inch, and the wave-length of light as 1/40,000th inch, this angle is found to be about two minutes." In the case of a small angle the aperture divided by the distance is approximately equal to the arc divided by the radius or to the circular measure of the angle. Hence in the present case we have $\frac{1/40{,}000\text{th inch}}{1/5\text{th inch}} = \frac{1}{8000}$ radian or $\frac{206{,}265}{8000} = 25{\cdot}8$ seconds nearly, instead of the two minutes accidentally stated by Lord Rayleigh.

This minimum value seems to show some mistake in Ehrenberg's experiments on vision, and is about half of that found by Helmholtz for the best of twelve observers.

March 10 SYDNEY LUPTON

[Mr. Lupton is quite right. By a stupid blunder I said about two minutes, when I should have said about half a minute.—RAYLEIGH.]

THERE is a defect of eyesight common among the natives of India known as "rátandhi," *lit.* "night blindness." Persons affected with this have either ordinary powers of vision by daylight, or else powers so little less than ordinary as to feel no inconvenience, so that usually no defect is noticeable; whilst in feeble twilight their sight fails in the most extraordinary way, and in the dusk they become (in bad cases) practically blind. Of course there are all degrees of this affection; but the strongly-marked cases alone are likely to attract attention.

By medical men in India this affection is said to occur most among men living on a low diet (chiefly of cereals), and the usual palliative treatment is to prescribe a meat diet.

This affection is rarely noticeable among Europeans in India, though I have sometimes noticed marked differences of clearness of sight among them also amounting to slight "night-blindness." Lord Rayleigh's case of short-sightedness in twilight and in the dusk seems to be a mild case of this sort (see NATURE, February 12, p. 340). ALLAN CUNNINGHAM

The Pupil of the Eyes during Emotion

ALTHOUGH further observations are required, there seems to be a more or less general assent as to the influence of the emotions on the pupils of the eyes. Mr. Clark, in his letter to your journal (vol. xxxi. p. 433), has rightly quoted Gratiolet, who says that in sudden astonishment or fear the whole system becomes paralysed, and at the same time the pupils dilated. In anger, on the other hand, when the whole body is roused into action, the pupils become contracted: "Les pupilles sont énormément dilatées dans l'épouvanté, tandis qu'elles sont toujours contractées dans le colère." This was, however, said many years before by the celebrated Harvey, who, in his discourse on the circulation of the blood, written in 1628, says: "In anger the eyes are fiery, and the pupils contracted" ("Irâ rubent oculi, constringitur pupilla").

I should myself think that a narrow pupil evinces a more active mental state, as it is this condition which is present when the eye is accommodated to regard with attention a near object, whilst, on the other hand, when gazing out into distance, the pupils are wider, and the mental mood is more passive and contemplative.

In my parrot the size of the pupil is a very excellent measure of its frame of mind. When angry the pupil becomes minutely contracted, whereas when the bird is sympathetic and amiable the pupils become as widely dilated. Balzac, with other novelists, have depicted the state of the pupils when describing the various emotions and passions. The former in pourtraying a saintly woman kneeling before the altar, says: "The pupil of the eye, endued with great contractility, appeared then to expand and draw back the blue of the iris until it formed no more than a narrow circle. What force was that arising in the depths of the soul which so enlarged the pupils in full daylight and obscured the azure of those celestial eyes?" Darwin speaks doubtfully, but rightly demands more observations on the subject. SAMUEL WILKS

Grosvenor Street, March

Auroræ

AFTER a long and remarkable absence of aurora, which, from a letter in your columns of February 19 (p. 360) does not appear to have been confined to these more southerly latitudes, we were favoured last evening with a beautiful, though somewhat transient display. It was about 9·25 p.m. when I first noticed a long band or belt of light above the northern horizon. At first it was ill-defined, with little change of position, but in about twenty minutes it became more luminous and the characteristic streamers suddenly made their appearance, shooting upwards, sometimes from above, sometimes from below the belt of light, which for a few seconds changed into a double arch. Some of these streamers rose as distinct columns, showing the usual prismatic hues, one in particular being noticeable as traversing the inverted W of Cassiopeia, another forming a fan-like terminus to the luminous region, but all confined to a low altitude, bounded on the north-west by Perseus, and on the north-east by Vega, then rising. It may be well to observe that on the same day (the 15th) a large sun-spot had just reached the central meridian, and was beginning to show signs of great disturbance. E. BROWN

Further Barton, Cirencester, March 16

Injuries caused by Lightning in Venezuela

IN answer to Mr. von Danckelman's inquiry as to the use of lightning-rods and the frequency of accidents from lightning in the tropics (NATURE, December 11, 1884, p. 127), I beg leave to offer the following information referring to Venezuela, where I have been residing ever since 1862:—

Thunderstorms are very frequent during the rainy season. They break out generally in the afternoon, about the time of the daily maximum of heat, whilst they are extremely rare in the morning (I only witnessed one case) and during the night. Statistics of accidents do not exist, nor are there many lightning-rods in use (in Caracas about half a dozen). But there are certain regions where the former are far from being uncommon, as, for instance, the country around the Lake of Valencia and the plains or *llanos* to the north of the Orinoco. In these a considerable number of cattle are killed by lightning every year, and I know also of several cases where houses were destroyed and people killed. The herds of cattle crowd together as soon as a thunderstorm begins, and the animals remain during the whole time with their heads down to the ground, thus avoiding instinctively that their pointed horns should act as lightning-conductors.

In the neighbourhood of Maracay, at the eastern end of the Lake of Valencia, accidents occur almost every year. A very

remarkable one was witnessed in 1883 by Dr. Manuel A. Diez, at that time physician of the military camp at Maracay. A lightning struck a *rancho* (small country house built of wood and mud, and thatched with straw or large leaves), where a man slept in a hammock, another lay under the hammock on the ground, and three women were busy about the floor; there were also several hens and a pig. The man in the hammock did not receive any injury whatever, whilst the other four persons and the animals were killed. As the wooden framework of the house was probably very dry, the man in the hammock was almost isolated; but the other persons and the animals were in direct contact with the floor—in this case the bare ground.

Near Caracas accidents are comparatively rare. During all the years of my residence here no more than six have come to my knowledge: in three of them some damage was done to buildings, in two cases large trees were split, and in one (October, 1882) a ploughman was killed while at work in the field, together with his two oxen, his driving-stick (about four yards long, and shod with an iron point) having acted as lightning-conductor. A. ERNST

Caracas, February 8

Mira Ceti

WITH reference to your note on Mira Ceti in NATURE of February 5, I beg to say that I have observed Mira since December 15, 1884, and my observations show that the star reached a maximum on February 4, when I estimated it equal to α Ceti, or about 2·7 magnitude. It remained of the same brightness up to February 13, and has faded very slowly since that date. It was, last night, not much below α Ceti.

J. E. GORE

Ballysodare, Co. Sligo, Ireland, March 8

Physical Geography of the Malayan Peninsula

I HOPE you will give me space in your journal to correct a few errors that have slipped into the letter under this heading in the issue of December 18 (p. 152) by the Rev. J. E. Tenison-Woods.

In the first place, there is no fluor-spar in the drift which carries the tin. The stone referred to is rose-quartz, some of which is very beautifully coloured. I have a specimen of it nearly as large as a man's head. It has a specific gravity of 2·63, and hardness equal to ordinary white quartz, which it will scratch without difficulty.

In the next paragraph Mr. Tenison-Woods says he cannot recall any mines on the eastern slopes of the mountains. This seems extraordinary, as some of the best mines in Kinta are on the eastern slopes of the valley, and I accompanied Mr. Tenison-Woods to the Lehat, Pasin, and Papan mining districts, and, with the exception of the Kwala, Diepang, and Gopeng mines, these were the only ones visited by him in Kinta, which were not on the eastern slopes of the valley. Following out the same idea, he says, speaking of the Kinta valley, "The river flows, like the Perak, on the eastern side of the valley." This is also a mistake, for it is decidedly on the western side, and this accounts for the fact mentioned in the next line: "The eastern tributaries are many and important." If the rivers were as stated by the rev. gentleman, this would be nearly impossible. I have taken the opportunity of asking the opinion of the officer in charge of the Kinta district, and he coincides with my view of the position of the river.

The next point on which I cannot agree is that "there is not the slightest sign of any recent upheaval of the coast-line, while the evidence of subsidence is equally absent. A short time ago a boring was made to a depth of 75 feet at Matang (which is the port of Larut), and I made a section from it, which shows that, within quite recent times, an important alteration of level has taken place. The ground at that place is 6 feet above the present high-water mark. Down to a depth of 17 feet from the surface the formation is marine, but below that, beds of sands, clays, and gravels, with leaf-bands and pieces of wood, are met with, of the same nature as the drift near the hills, and containing a small quantity of fine tin; these beds extend down to a depth of 75 feet, and most probably much further. It therefore appears that there has been a subsidence of at least 75 feet since the formation of the tin-bearing drift of Larut. An alteration of level of this extent must have made most important geographical changes in the Straits of Malacca, and may help to solve many of the problems connected with the distribution of the flora and fauna of this interesting locality.

The limestone-hill on the eastern side of the Gapis Pass, called Gunong Pondok, is 1800 feet in height, instead of 400 feet, as stated; and is connected by a ridge with the main range of mountains. A little further on Mr. Tenison Woods says that there are *two* mountains called Gunong Hijau. This is a very excusable mistake for a stranger to make, for one is Hijau, which means "green," and the one further to the north is Ijoh, which is the name of a palm (*Arenga saccharifera*). The Kurau river has its source on the former mountain, at the back of the town of Thaipeng. About four years ago I followed the stream from near the summit of Hijau down to the plains.

L. WRAY, Jun.

Perak Museum, Larut, Perak, January 30

The Continuity of Protoplasm in Plant Tissue

THERE is some danger that those who are unable to make a personal examination of the Florideæ may be a little misled by Mr. Gardiner's remarks thereon in his article on "The Continuity of the Protoplasm in Plant Tissue" (NATURE, vol. xxxi. p. 390). In arguing in support of his own view that this continuity is not direct, but indirect he states that "Schmitz has found that a pit-closing membrane," "perforated in a sieve-like manner," exists in the Florideæ, and that he himself has "been able to confirm Schmitz's results as to the existence of the closing membrane in question."

Now, if Mr. Gardiner means by this that what he terms a pit-closing membrane, perforated in a sieve-like manner, is present in *all* the Florideæ, or even in *all parts* of the thallus of a single species, I venture to submit that the statement is not in strict accordance with fact. In my investigations into the histology of these plants, special attention was paid to this point, and by no methods that I could devise, or learn from other workers, was such a membrane to be demonstrated in the simpler forms, as, for example, in *Petrocelis cruenta*. Indeed, I cannot conceive how a sieve-plate arrangement could possibly exist, where the continuity is maintained by *a single thread of protoplasm*, and that of such extreme tenuity as in the species referred to. So far as I am aware, no one maintains the existence of a sieve-plate in the threads of Volvox, and I fail to see why it should be assumed to exist in the equally fine threads now under consideration.

Further, in *Polysiphonia*, *Ptilota*, and other genera, where a membrane is normally present, it is *not* met with *in every part* of the thallus, being absent from the younger portions. In these portions the connecting threads are *single* and *extremely delicate*, so that while observation affords no indication of a sieve-plate, the arrangements themselves preclude the possibility of one. As the threads grow older and thicker, a membrane which may be perforated is developed, but it is no part of the primary wall of the protoplast. Thus, while the connecting protoplasmic threads exist from the first, the so-called pit-closing membrane arises as *a later development*, and is therefore *subsidiary to the continuity*, and *not essential* to it.

So far, then, as the Florideæ are concerned, I think we must recognise two conditions or stages of continuity; first, a direct continuity, permanent in the simpler forms, but transitory in the more complex ones; and second, an indirect continuity, absent from the younger, but present in the older tissues.

Harrogate, March 7 THOMAS HICK

Time in the United States

IN your issue of January 23 the statement (p. 277) that "local time throughout the United States, as opposed to railway time has been abolished," is not quite accurate. At the introduction of the "standard" time an attempt was made in many places to do this, but it has proved impracticable, except near the meridians of time. At other places the local time still governs all the daily business, except what involves travelling. For this the difference, a constant quantity, is remembered, and the proper allowance made. For example, here we allow thirty-three minutes, being west of the meridian of eastern time to that amount. E. W. CLAYPOLE

Akron, Ohio

FACILITIES FOR BOTANICAL RESEARCH

THE botanical student who has successfully passed his final examination at one of our universities or local colleges will naturally begin to consider to what use he can devote the knowledge of facts and methods which he has acquired. To many it is unfortunately necessary to turn at once to some employment which will bring in a substantial return. Teaching pays; research does not; so the latter is often out of the question. But the few to whom earning money is not an immediate necessity hardly realise the splendid possibilities which lie before them. Of these men of more or less independent means some, from pure inertness, may be content to move within the narrow circle of their own university; others, following the example of their predecessors, will start on the German pilgrimage and sit at the feet of one or other of those teachers whose names they have long venerated from a distance. The advantage of working under the direction of one of these masters is no doubt very great, but still Germany lies in the temperate zone; the flora approximates nearly to that of Great Britain, and the gardens and hot-houses are in no way superior to our own. It rarely enters into the calculations of a young graduate that a journey to the tropics is a possible alternative to the German pilgrimage; yet a circular recently issued by Dr. Treub, the well-known Director of the Botanical Garden at Buitenzorg, in Java, shows us that a visit of six months to the island is well within the range of any man who has 200*l.* to spend upon it. It is true that this expense is decidedly greater than that of living for six months in a German University town, but the advantages are correspondingly greater. In the first place, a tropical vegetation offers ample opportunities for research, especially in the branches of morphology and anatomy: in proof of this it is sufficient to turn over the pages of the *Annales du Jardin botanique de Buitenzorg*, and note the valuable results there detailed, chiefly from the pen of Dr. Treub himself; secondly, the Government of the Dutch Indies has recently placed suitable buildings at the disposal of the Director, who finds that he now has accommodation in his laboratory for four foreign investigators to work simultaneously; again, in the person of Dr. Treub, who, it may be mentioned, is a proficient in the English language, there is constantly present at Buitenzorg one of the first investigators of our time. In his circular Dr. Treub combats the idea which most of us would probably entertain, that Buitenzorg, being in the tropics, is necessarily unhealthy: he states that, though he will not pretend that a stranger coming to stay for four or five months cannot possibly fall ill, still the chances of contracting disease during that time are not notably greater than if one stayed at home or travelled on the continent of Europe. He recommends the period between October and April as the best, both as regards health, comfort, and the vegetation. Here is an opportunity the like of which has perhaps never before been offered to students, and one which can best be embraced by those who have not yet assumed the yoke of regular employment.

These facilities for botanical research in a tropical climate, thus offered freely to strangers by the Dutch, naturally suggest to the English mind that with all our colonies we have at present little of a like nature to offer: we have in our gardens at Calcutta and Peradeniya as good chances of establishing laboratories for botanical research as the Dutch had at Buitenzorg Prof. Haeckel's interesting account of his recent tour in Ceylon, and of his visit to Peradeniya, gives some idea of the scope there would be for a young botanist to carry on morphological and anatomical work In the sphere of thallophytic botany Mr. H. M. Ward has already shown that a lengthened stay in the tropics may lead to the attainment of very valuable results.

But without going so far afield as the tropics, and at a decidedly less cost than such a journey would entail, plenty of scope may be found for satisfying the desire to investigate. Thus at the well-known marine biological station at Naples, the tables which are habitually occupied by zoologists might well be applied for by botanists: the numerous botanical memoirs issued from this institution by continental observers show that the institute of Dr. Dohrn is well adapted for the investigation of marine algæ as well as of marine animals.

A second marine station, devoted more particularly to the study of botany, is that at Antibes, now in the possession of the French Government; it was formerly the private residence of M. Thuret, to whose researches, in conjunction with M. Bornet, we owe so much of our knowledge of the reproductive processes of marine algæ. Being compelled, for the sake of his health, to pass the winter months in the south, M. Gustave Thuret chose the beautiful promontory of Antibes for his residence. He laid out the grounds surrounding his villa as a winter garden, collecting together many rare and beautiful plants; at the same time, while attending to the collection and correct identification of terrestrial forms, he availed himself of the opportunity presented by residence on the coast to apply himself with vigour to those researches on marine algæ with which his name will always be connected. On his death in 1875, Mdme. Henri Thuret, desiring that the valuable collections of her brother-in-law should not be dispersed, bought the property for a sum of 200,000 francs, and presented it to the nation, the State undertaking the expenses of its maintenance. M. Naudin was appointed as director of the new institution. It is understood that on suitable application being made, foreigners can obtain admission to the laboratories of the Villa Thuret, which offer exceptional opportunities for the study both of marine and terrestrial forms.

However great the advantage may be of visiting countries of a climate different from our own, it is far from being necessary for an English student to leave his own country in order to satisfy his desire for research: the methods in use in the botanical laboratory are now taught with precision in our Universities: any student who has passed his final examination in the first class should be in a position to conduct a research successfully, if he has in him the necessary mental qualities. To such a man the resources of the Royal Gardens at Kew are a real mine which shows no sign of exhaustion. Not only may an investigator obtain access to the unrivalled collections, both living and dry, of the Royal Gardens, but, since Kew is in constant communication with distant countries, materials for completing a research may often be obtained which could scarcely be accessible in any other way. Through the munificence of the late Mr. Jodrell, a well-appointed laboratory has been erected in the Gardens, with the express object of encouraging research.

Lastly, it must be admitted that the poverty of our efforts in recent years to investigate the marine algæ of our coasts is little short of a disgrace to us as a maritime nation. Even our commonest sea-weeds are so little understood that they would well repay a careful investigation. Work on the sea-coast must for the present depend upon individual enterprise; but we may hope that shortly, when the Marine Biological Association has a fixed abode, botanists may be found ready to make a proper use of the opportunities which they will then enjoy.

In view of the constantly increasing bulk of botanical publications, which may be taken as an index of a steady increase in activity of research, it may be thought that it is more difficult at the present day to strike out an original line than at earlier periods in the development of the science. But, against this great increase of our

knowledge we must set the more systematic training to which students are subjected before they are expected to take an independent line; secondly, the new methods of treatment and new points of view which now succeed one another more rapidly than at any previous time; and, thirdly, the very greatly increased facilities for research on the spot in foreign countries. When it is remembered how many of our most prominent men started their careers as travellers, the importance of the third of the above considerations will be valued as it ought to be. Those who are best able to appreciate the position of anatomical and physiological botany would probably be the first to agree that the opportunities for research in these branches, either in foreign lands or at home, are, at the present moment, better than they have been at any former period in the history of the science. If the botanical students of the present day content themselves with devoting their time and energy to working out small and uninteresting details, it is their own poverty of imagination and want of enterprise that are to blame.

F. O. B.

MOLECULAR DYNAMICS[1]

I HAVE placed the three titles above this article not because I intend to deal with more than the last, but because they all deal with the same matter, and show how much the author's attention was directed to the subject during his three months' sojourn in America. The audience at the Baltimore lectures consisted chiefly of American professors, and a few English men of science attended a larger or smaller number of the lectures.

Speculation was rife as to the probable character of the lectures, and there was a general feeling that vortex motion would be largely dealt with. This, however, was not so. The course of twenty lectures was confined to the wave theory of light, largely dealing with the difficulties of that theory. The published lectures are not printed, but "jelligraphed," as Sir William Thomson would say. The number of copies is extremely limited, and are of unique interest, being reproduced from the short-hand notes taken at the lectures. Every one who knows how suggestive Sir William's lectures are and how fertile his mind is in bringing illustrative digressions to bear on the topic in hand, will expect these verbatim notes to be a rare treasure. Nor will he be disappointed. Mr. Hathaway, the reporter, has the unusual combination of being an expert stenographist, a skilful mathematician, and a clear and distinct caligraphist. His notes contain numerous errors, such as are unavoidable in such an undertaking, but, viewed as a whole, his work is almost a marvel.

The lectures treated of three branches of the subject: (1) the propagation of a disturbance through an elastic medium; (2) the character of molecular vibration; and (3) the influence of molecules on the propagation of waves. Each lecture generally dealt with two of these branches, and between the two parts of the lecture Sir William went among his andience and had some conversation with them. It was ever his object to discard the professorial attitude and give his lectures the aspect of conferences. Discussion did not end in the lecture-room, and the three weeks at Baltimore were like one long conference guided by the master mind. It is not surprising that at the end of that time there was a genuine feeling of sadness at parting on the part of teacher and taught alike.

The part of the lectures dealing with the propagation of an elastic disturbance could not be expected to contain much novelty, but it was treated in so novel a manner and from so purely a physical point of view, that it could not but be instructive. Many of the old supporters of the theory dealt with it purely from a mathematical point of view. They treated the problem as a mathematical exercise, and did not hesitate to make unwarranted assumptions to produce pretty formulas or simple solutions. Even such men as Weber (in his "Theory of Magnetism") and Green (in his "Wave Theory") have been guilty of this practice. Sir William Thomson never made any but physical assumptions, and these were made for reasons given. Rather than make a meaningless mathematical assumption he would prefer to burden his formulas with undetermined quantities, and even, if unable to reach the final solution, would rejoice in the richness of the formulas, which showed a potentiality of overcoming many difficulties. He does not always commend Rankine's mathematics, but he says this for him at p. 185: "Rankine did a great deal to cure the mathematical disease of *asphasia* from which we suffered so long. Faraday did most. The old mathematicians used neither diagrams to help people to understand their work, nor words to express their ideas. It was formulas, and formulas alone. Faraday was a great reformer in that respect with his language of 'lines of force,' &c. Rankine was splendid in his vigour and in the grandeur of his Greek derivations." This refers to Rankine's nomenclature of different kinds of moduluses and their reciprocals—*e.g. plagiotatic, thlipsinomic*, &c.

The first lecture is a summary of what is to come, and is partly historical. The difficulties in the way of accepting the wave theory of light are clearly pointed out. These are four in number.

First Difficulty: Dispersion.—The difficulty is to explain how velocity of propagation depends on period of vibration. Two explanations have been offered, that of Cauchy and that of Helmholtz. He does not delay much with Cauchy, who ascribed it to heterogeneousness. He prefers Helmholtz, who ascribes it to a compound structure of material molecules, which gives them a natural period of vibration. The one explanation has relation to wave-length, the other to period of vibration. The latter, he thinks, falls in better with results of spectrum analysis, &c. A great portion of the lectures is devoted to expanding the notion of Helmholtz. The space occupied by a molecule must be filled with a substance differing from the ether either in rigidity or in density, or both. Lord Rayleigh has taken in hand this question in his researches on blue sky, and it seems that a variation of density is the principal or only effective cause. With respect to the new (Helmholtz-Thomson) spring and shell molecule, he says, "It seems to me that there must be something in this, that this, as a symbol, is certainly not an hypothesis, but a certainty."

Second Difficulty: the Ether.—He makes short work of the difficulty of reconciling almost perfect rigidity with almost perfect mobility. It is merely a matter of time. You can make a tuning-fork of Burgundy pitch when the period is a small fraction of a second, but a bullet will pass clean through several inches of it in six months. The ether may be highly elastic for vibrations executed in the 100 or 1600 million millionth of a second, but highly mobile to bodies going through it at the rate of twenty miles a second.

Third Difficulty: Refraction and Reflection.—Theoretical equations agree qualitatively with facts, but there are serious discordances when we come to quantitative measurements. Especially is this the case in the completeness of extinction of the ray polarised by reflection.

Fourth Difficulty: Double Refraction.—It is found that when the medium is displaced during wave-propagation in a double refracting crystal, the return force must depend on the direction of vibration, not on the plane of distortion, as all elastic theories indicate. Rankine and

[1] "On Molecules," the Presidential Address to Section A of the British Association, August, 1884, by Sir William Thomson.
"The Wave Theory of Light," a Lecture delivered by Sir William Thomson at Philadelphia on Sept. 29, 1884, published in NATURE, vol. xxxi. p. 91.
"Lectures on Molecular Dynamics," by Sir William Thomson, Johns Hopkins University, October, 1884.

Rayleigh independently invented unequally loaded molecules which overcome the difficulty, but give a wave surface different from Huyghens', and Stokes has proved experimentally that Huyghens' construction is very accurate. Hence this way of escape is denied to us.

In treating of the propagation of waves in an isotropic (and later in an aeolotropic) medium, methods of Thomson and Tait's Natural Philosophy, and his own article, "Elasticity," in the "Encyclopædia Britannica," are used; $a\,b\,c$ are distortions about Ox, Oy, and Oz, $e\,f\,g$ are dilatations along Ox, Oy, Oz. The equation of the energy E is a quadratic in $a\,b\,c\,e\,f\,g$, containing twenty-one coefficients, some of which are annulled by isotropy.

If

$$P = \frac{dE}{de},\ Q = \frac{dE}{df},\ R = \frac{dg}{dE};$$
$$S = \frac{dE}{da},\ T = \frac{dE}{db},\ U = \frac{dE}{dc},$$

and if ρ be the density, and ξ a displacement along Ox, we obtain the equation

$$\rho\frac{d^2\xi}{dt^2} = \frac{dP}{dx} + \frac{dU}{dy} + \frac{dT}{dz}.$$

Moreover, if n be the rigidity modulus, k the bulk modulus, δ the cubic dilatation, and $m = k + \frac{1}{3}n$, we have

$$P = (m - n)\,\delta,$$
$$T = n\left(\frac{d\xi}{dz} + \frac{d\zeta}{dx}\right),$$

with similar expressions for Q, R, S, U.

Thence he shows that the equation

$$\rho\frac{d^2\xi}{dt^2} = m\frac{d\delta}{dx} + n\nabla^2\xi,$$

(with the condition $\frac{du}{dx} + \frac{dv}{dy} + \frac{dw}{dz} = O$ in an incompressible substance), contains every possible solution, and he proceeds to discuss special cases of the general solution which may be true of waves propagated by molecules through the ether. Here his desire for physical conceptions appears, and his hatred of mathematical *asphasia*. He considers the case of a ball moving to and fro, of a ball twisting about an axis, of a globe becoming alternately prolate and oblate, of a rod twisted in opposite directions at the two ends, and of the Thomson-Helmholtz molecule which is a heavy mass connected by massless springs with a massless inclosing shell, or there may be several shells inclosing each other, connected by springs with a dense mass in the centre (far more dense than the ether).

Here he discusses the manner in which a molecule may be supposed to give off its vibrations to the ether. Does it gradually increase in intensity and gradually die out, or how does it act? Here is what he says on this much-neglected point at p. 94:—

"The kind of thing that the luminous vibrator consists in seems to me to be a sudden initiation of a set of vibrations and a sequence of vibrations from that initiation which will naturally become of smaller and smaller amplitude. . . . Why a sudden start? Because I believe that the light of the natural flame or of the arc light or of any other known source of light must be the result of sudden shocks from a number of vibrators. Take the light obtained by striking two quartz pebbles together. You have all seen that. There is one of the very simplest sources of light. . . . What sort of a thing can the light be that proceeds from striking two quartz pebbles together? Under what circumstances can we conceive a group of waves of light to begin gradually and to end gradually? You know what takes place in the excitation of a fiddle-string or a tuning-fork by a bow. The vibrations gradually get up from zero to a maximum, and then, when you take the bow off, gradually subside. I cannot see anything like that in the source of light. On the contrary, it seems to me to be all shocks—a sudden beginning and gradual subsidence."

The light coming from a single shock is, of course, polarised always in the same direction. Sellmeier's deductions from Fizeau's experiment shows that there is no serious fading in 50,000 vibrations. Helmholtz introduces viscous terms which absorb the energy and might prevent the possibility of 50,000 vibrations from one shock. That is a retrograde step. Absorption can be explained without viscous terms.

Such speculations, when coming from one of less grasp of physical facts, would attract but little attention. But here all kinds of useful suggestions are continually thrown out for experiment and for hypotheses. He is striving to get at the physical meaning of radiation, absorption, anomalous dispersion, fluorescence, and phosphorescence, and here is what he says on some of these points at p. 90:—

"But there are cases in which we have that tremendous jangling, and that is in the fluorescence of such a thing as uranium glass, which lasts for several seconds after the exciting light is taken away, and then again in phosphorescence that lasts for hours and days. There have been exceedingly interesting beginnings in the way of experiments already made, but I think no one has found whether initial refraction is exactly the same as permanent refraction. For this purpose we might use Becquerel's phosphoroscope, or we might take such an appliance as Prof. Michaelson has been using for light, and get something enormously more searching than Becquerel's phosphoroscope, and try whether, in the first hundredth of a second, there is any indication of a different wave-velocity from that which you would have when white light passes continuously in the usual manner of refraction. If in the methods employed for ascertaining the velocity of light in a transparent body . . . we apply a test for an instantaneous refraction, I have no doubt we shall get negative results, but yet properties of ultimate importance. We might take bodies in which, like uranium glass, the phosphorescence lasts only a few seconds; and then, again, bodies in which phosphorescence lasts for minutes and hours. With some of these we should have anomalous dispersion, gradually fading away after a time. I should think that by experimenting, and so on, we should find some very interesting results of this kind."

In his mathematics he suppresses the condensational wave, and, in doing so, makes reference to the electro-magnetic theory of light, which, he thinks, has added nothing to our physical conceptions of the ether. In treating, further on, of reflection and refraction, he speaks a great deal of the pressural wave, which many authors have called a condensational wave. I find that in some points my notes are fuller than the reporter's. I cannot find there the following characteristic passage about the pressural wave:—"People have tried to muddle this. The pressural wave has been the difficulty. Cauchy starved the animal, M'Cullagh and Neumann didn't know of its existence, Haughton put it in an Irish car and it wouldn't go, Green and Rayleigh treated it according to its merits."

With regard to the possibility of a condensational wave, and to the electro-magnetic theory of light, we find, on pp. 40-41:—

"We ignore this condensational wave in the theory of light. We are sure that its energy, at all events, if it is not null, is very small in comparison with the luminiferous vibrations we are dealing with. But to say that it is absolutely null would be an assumption we have no right to make. When we look through the little universe that we know, and think of the transmission of electrical force and of the transmission of magnetic force, and of the transmission of light, we have no right to assume that there is not something else that our philosophy does

not dream of. We have no right to assume that there may not be condensational vibration in the luminiferous ether. We only do know that any vibrations of this kind which are excited by the reflection and refraction of light are certainly of very small energy compared with the energy of the light from which they proceed. The fact of the case as regards reflection and refraction is this: that, unless the luminiferous ether is absolutely incompressible, the reflection and refraction of light must generally give rise to waves of condensation. Waves of distortion may exist without waves of condensation, but waves of distortion cannot be reflected at the boundary surface between two mediums without exciting in each medium a wave of condensation. When we come to the subject of reflection and refraction we shall see how to deal with these condensational waves, and find how easy it is to get quit of them by supposing the medium incompressible. But it is always to be kept in mind to be examined into: Are there or are there not very small amounts of condensational waves generated in reflection and refraction; and may, after all, the electric force not depend on the waves of condensation? Suppose that we have at any place in air, or in luminiferous ether, a body that, through some action we need not describe, but which is conceivable, is alternately positively and negatively electrified: may it not be that this will be the cause of condensational waves?" It is then supposed that two spherical conductors are connected to the terminals of an alternating dynamo machine, and the quotation proceeds:—

"It is perfectly certain, if we turn the machine slowly, that in the neighbourhood of the conductors we will have alternately positively and negatively electrified elements with reversals perhaps two or three hundred per second of time, without a gradual transition from negative through zero to positive, and the same thing all through space; and we can tell exactly what is the potential at each point. Now, does any one believe that, if that revolution was made fast enough, the electrostatic law would follow? Every one believes that, if that process be conducted fast enough several million times, or millions of million times per second, we should be far from fulfilling the electrostatic law in the electrification of the air in the neighbourhood. It is absolutely certain that such an action as that going on would give rise to electrical waves. Now it does seem probable to me that electrical waves are condensational waves in luminiferous ether, and probably it would be that the propagation of these waves would be enormously faster than the propagation of ordinary light waves. I am quite conscious, when speaking of this, of what has been done in the so-called electro-magnetic theory of light. I know the propagation of electric impulse along an insulated wire surrounded by gutta-percha, which I worked out myself about the year 1854, and in which I found a velocity comparable with the velocity of light. . . . That is a very different case from this, and I have waited in vain to see how we can get any justification of the way of putting it in the so-called electro-magnetic theory of light."

In those parts of the lectures which deal with wave propagation in an isotropic medium, by far the most interesting parts are those which treat of the conditions at bounding surfaces, whether these surfaces be reflecting and refracting surfaces or surfaces of radiating molecules, or surfaces of absorbing molecules. Lord Rayleigh's investigations and his own on the likelihood of the density or the rigidity of the substance composing a molecule differing from that of the ether are also full of interest

Much of this part of the subject has been thoroughly worked out before, but here the treatment is so original, the language is so suggestive, and I need hardly say that the whole course of lectures is so pregnant with useful ideas, that every one who reads this part will be well repaid.

Having now roughly indicated the novel points and the general mode of treatment of the problem in *molar* dynamics, I propose in the next notice to give some account of the problem in *molecular* dynamics, which occupied half of the time. GEORGE FORBES

(*To be continued.*)

THE LONG DURATIONS OF METEORIC RADIANT POINTS

IT is unfortunate that the observation of shooting stars is associated with difficulties of no common order. The very large number of distinct showers visible at the same epoch, their extremely attenuated character, and the many impediments to accurate determinations of the flights of the individual shooting stars proceeding from them, exercise an unfavourable influence on the work and deter many observers from grappling with a subject which is admittedly beset with such perplexing details. Apart from this, there exists the great necessity for observations to be sustained during the whole night, and this is rarely practicable either by amateur or professional astronomers, who generally have other important work in hand. In fact, meteoric astronomy requires the almost exclusive attention of the observer, and must be closely pursued for a long period of time if anything like comprehensive results are to be obtained. The voids occasioned either by moonlight or cloudy weather in a short series of observations are only to be filled up by prolonged watches extended over many consecutive years.

The long visible duration of a large number of radiant points of shooting stars is, it must be confessed, a fact which defies satisfactory explanation. The ingenious theory which had attributed to meteor streams an identity with cometary orbits, required that the visibility of such streams should be of very brief character, though in the case of an abnormally wide system or of a shower directed from a point near the earth's apex the duration might be longer than usual, but the radiant point could not maintain a perfectly fixed position amongst the stars. This general view of the subject is, however, not accordant with the results of recent observations, for while there are undoubtedly some cometary showers which display all the peculiarities taught by theory, there are many other streams which continue visible for several months and retain a stationary position in the firmament. It is evident therefore that these streams are presented to us under totally different circumstances as regards orbit to the true planetary showers, and are amenable to conditions and laws which form a problem the solution of which is arrested by no ordinary difficulties.

The multiplicity of streams would naturally originate a false appearance of long duration in certain radiant points, but observations of very precise character would soon show that the point of radiation, as successively determined, differed considerably, being not, in fact, confined absolutely to the same point in the sky. But it is now proved that there are no differences, other than those introduced by small unavoidable errors of observation, in the centres from which shooting stars continue to fall during several months. Indeed, it seems a probable inference from the observations that some showers exist all the year round, though not visible during the epoch when they are very near to the sun.

That such long enduring radiants of meteors can have a community of origin and belong to physically associated streams in the same degree as the true cometary meteor showers is very difficult to understand. But the fixity of the radiant over so long an interval would yet seem to indicate some bond of close affinity existing between them. At any rate we have no reason to suppose that a large number of showers, distinct in themselves, can occur consecutively from the same points of the sky owing to a common peculiarity of grouping.

At intervals of six months the earth's motion in space is in exactly opposite directions, and yet these streams of meteors enter the atmosphere from the same apparent radiants. Evidently therefore the meteoric particles, which individually move in parallel flights, are travelling independent of solar attraction and are presented to us under a totally different aspect to the cometary showers the phenomena of which are clearly understood.

If meteoric streams of great width are encountered by the earth as the result of the sun's proper motion in space then it would appear that to give the phenomena of stationary radiants they must move with enormous velocities. This is not borne out by the observations, for the meteors of these long-enduring streams exhibit appearances similar to what is generally observed in the meteors from the cometary showers. The farther the radiant is removed from the earth's apex the slower become the motions of the meteors, they lose the streak-generating capacity, and their colour changes from white to yellow or red, indicating a lower degree of incandescence as the result of a less violent friction with the atmosphere. There are exceptions, however, for the meteors from some radiants retain a velocity much greater than that theoretically assigned.

There is a very pressing need for further observations specially directed to the visible trajectories of shooting stars. The apparent motions of the corpuscles belonging to a stream depend upon several conditions which are very liable to originate discordances. The particles near the radiants move slowly in short courses owing to foreshortening, and when the radiant is near the horizon the flights are longer and more gradual than when it has reached a considerable altitude. The Geminids of December, for instance, appear very slow in the early hours of the evening, but in the morning their swift, diving courses would lead the observer to attribute them to an entirely separate family were it not that the radiant occupies an identical place to that determined

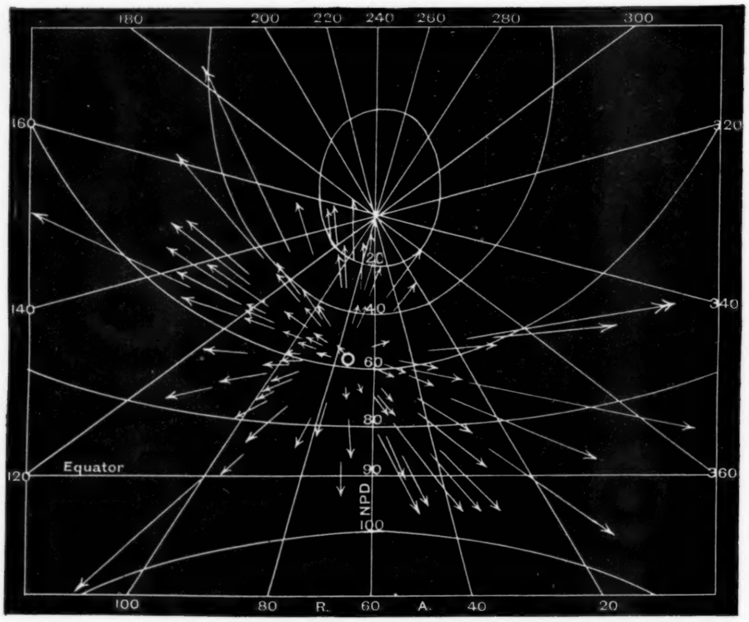

FIG. 1.

from the slower meteors recorded several hours before. Some showers also doubtless furnish meteors which become igneous at greater distances than others and more relatively slower than those belonging to streams formed of materials not so readily combustible. Moreover the specific gravity of the particles of different systems probably varies to some extent, and their individual forms may not always coincide, so that the effects of atmospheric resistance must necessarily introduce peculiarities in the observed flights.

The idea occurred to me that these long-enduring radiants must result from terrestrial meteor streams, *i.e.* streams revolving around the earth in an excentric orbit with perigee near the outer limits of the atmosphere. If streams of this character existed and were closing in upon the earth we should have the phenomena of stationary radiants. And the fact of their closing in upon us would be rendered possible on the assumption of a resisting medium (similar to that affecting the motion of Encke's comet), or that at each return to perigee the atoms encountered the tenuous outer region of the atmosphere, which, though not sufficiently dense to render them incandescent, would slightly diminish their velocity and thus bring about a contraction of the orbit. But there are difficulties to the adoption of such views, one of which is that the meteors from such streams would exhibit a consistency of velocity whatever the relative position of their radiants with regard to the earth's direction of motion, and this does not accord with the facts of observation.

The earth's atmosphere probably extends in a barely appreciable degree a much greater distance than ordinary estimates allow. The computed heights of certain meteors deduced from multiple observations, and the phenomena of minute, telescopic shooting stars, which are evidently far exterior to ordinary naked eye meteors, render this highly probable. The former are very numerous, though to what degree is only known to those who have been habitually engaged in sweeping the heavens with a telescope of low power and large field. According to my

own observations telescopic meteors exceed the more conspicuous class of these bodies in the proportion of about 40 to 1. Rich showers probably exist only visible with instrumental means, and certain showers readily perceptible to the naked eye afford little indication of their existence with telescopic aid. The Geminids may be ranked among the latter, for on December 12, 1877, Lewis Swift at Rochester, whilst comet seeking during a period of $4\frac{1}{2}$ hours, noticed a large number of naked eye meteors. They frequently intruded upon his attention in the intervals when his eye was withdrawn from the telescope, and his estimate of the number visible was 1000 for the whole period of his observations. Yet, singularly enough, there was an unusual paucity of telescopic meteors, only two certainly, and one other suspected, crossing the field of view of $1\frac{1}{2}°$, whereas they are usually of frequent occurrence.

The observation of meteors, both telescopic and otherwise, especially commends itself to amateurs as an attractive study, requiring no elaborate or expensive instruments. The inconveniences attending such work may soon in great measure be overcome by patience. In cases where the results are thoroughly reliable we think that even slender observations possess weight and ought to be encouraged, for such results soon accumulate, and if

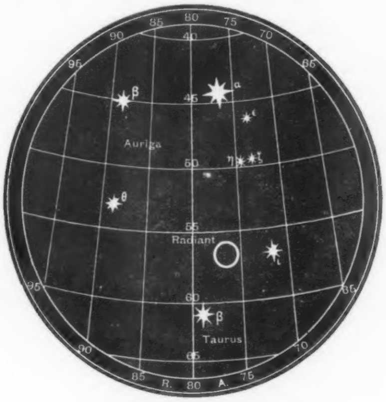

FIG. 2.

allowed to extend over several years may be combined and reduced to very satisfactory issues. Or the materials obtained by different observers for similar epochs might be collected and the radiant points determined from a careful analysis of the path-directions. In every instance, however, the physical appearances of the meteors ought to be fully described and given due weight in fixing the radiants. Without these precautions it is impossible to obtain reliable positions or to arrange the meteors into family groups with anything like that precision which is an essential feature of the work.

It is earnestly hoped that more enthusiasm may now be aroused amongst observers in this interesting department of astronomy. The question as to the duration of radiants and their absolutely fixed position must have an important bearing on the theory of their origin, and deserves much further investigation. The apparently intermittent character of many such streams also deserves notice, as their fluctuations may be regulated by definite periods of short duration. The observations of individual radiants should be confined to a few nights only, or when, from the paucity of meteors, it is found necessary to include results extending over several weeks, the nights of greatest intensity should be mentioned. The necessity exists for equal accuracy in deducing the radiant points, as in registering the exact directions of flight; in fact, great discrimination and precision are required in details so mutually dependent, so liable to errors, and so full of complications.

One of the most active and at the same time one of the most precise and well-defined cases of long duration is exhibited by a meteor shower in the southern extremity of Auriga and slightly to the north-east of a line connecting the stars ι Aurigæ and β Tauri. It gives the first sign of its existence at the end of July, and thence continues during several ensuing months. The epochs about October 8–15 and November 7 and 20 would appear to represent the most prominent exhibition of this radiant, though there are many other nights during the summer and autumnal months when it may be detected during a prolonged watch. The accompanying diagram (Fig. 1) shows the projected paths of eighty meteors (chiefly observed by myself at Bristol, and selected as being tolerably near the radiant point) recorded during the months of October and November. These paths form only a proportion of the aggregate number seen, but they sufficiently display the singularly precise radiation of this stream. A similar diagram might readily be prepared from the flights recorded in August and September when the convergence of an almost equal number of meteors attest the visibility of the same radiant. Its position relatively to the stars is given in Fig. 2, and it is hoped that observers will endeavour to effect its re-observation. We require further observations particularly during the month of August, when the radiant is very low, until the morning hours, and this doubtless accounts for the rareness of its apparition at that epoch. W. F. DENNING

NOTES

THOSE who are interested in the South Kensington Museum will be glad to learn that the National Collections belonging to the Science Department have now a prospect of improvement. A Government Committee has lately been appointed to report generally upon them and to consider plans for properly housing them. The Committee consists of gentlemen of high position in various Government Departments; the Chairman is Sir Frederick Bramwell, F.R.S., and Dr. W. Pole, F.R.S., is the Secretary.

THE Prince of Wales, President of the International Inventions Exhibition, has fixed Monday, May 4, for the opening of the Exhibition. Rapid progress is being made in all branches connected with the Exhibition. The large space set apart for machinery in motion is already being filled, whilst preparations for receiving other exhibits are well forward, some of which have arrived at the building. The Aquarium Department is receiving considerable attention, and will form a very attractive feature. The tanks have been thoroughly cleansed and refilled with fresh water, which has been softened and filtered, rendering it bright and pure, fit for the reception of large consignments of fish that will shortly arrive. Lord Onslow has lately presented 1500 exceedingly fine carp to the Aquarium, and a large number of fish indigenous to the Canadian Lakes have also been received for exhibition in the tanks.

THE Royal Society of New South Wales offers its medal and a money prize for the best communication (provided it be of sufficient merit) containing the results of original research or observation upon each of the following subjects:—Series IV. To be sent in not later than May 1, 1885:—No. 13. Anatomy and life-history of the Echidna and Platypus; the Society's Medal and 25*l*. 14. Anatomy and life-history of Mollusca peculiar to Australia; the Society's Medal and 25*l*. 15. The chemical composition of the products from the so-called Kerosene Shale of New South Wales; the Society's Medal and 25*l*. Series V. To be sent in not later than May 1, 1886:—No. 16. On the chemistry of the Australian gums and resins; the

Society's Medal and 25*l*. 17. On the tin deposits of New South Wales; the Society's Medal and 25*l*. 18. On the iron-ore deposits of New South Wales; the Society's Medal and 25*l*. 19. List of the marine fauna of Port Jackson, with descriptive notes—as to habits, distribution, &c.; the Society's Medal and 25*l*. Series VI. To be sent in not later than May 1, 1887:—No. 20. On the silver-ore deposits of New South Wales; the Society's Medal and 25*l*. 21. Origin and mode of occurrence of gold-bearing veins and of the associated minerals; the Society's Medal and 25*l*. 22. Influence of the Australian climate in producing modifications of diseases; the Society's Medal and 25*l*. 23. On the Infusoria peculiar to Australia; the Society's Medal and 25*l*. The competition is in no way confined to members of the Society nor to residents in Australia, but is open to all without any restriction whatever, excepting that a prize will not be awarded to a member of the Council for the time being; neither will an award be made for a mere compilation, however meritorious in its way—the communication, to be successful, must be either wholly or in part the result of original observation or research on the part of the contributor. The successful papers will be published in the Society's annual volume. Fifty reprint copies will be furnished to the author free of expense. Competitors are requested to write upon foolscap paper, on one side only. A motto must be used instead of the writer's name, and each paper must be accompanied by a sealed envelope bearing the motto outside and containing the writer's name and address inside. All communications to be addressed to the honorary secretaries, A. Liversidge and A. Leibius.

A LECTURE on "Cholera, what it is, and how it may be guarded against," will be given by Prof. Burdon-Sanderson at Toynbee Hall, 28, Commercial Street, E., on Thursday, March 26, at 8.15 p.m.

A MEETING of scientific men was held on Saturday at the University College, Liverpool, at which it was resolved to prepare a scheme for investigating the marine fauna of the neighbouring seas, so that a commencement of the work might be made during the ensuing summer. Prof. Herdman had the organising and details entrusted to him.

THE Duke of Westminster and the Committee of the Sunday Society have issued invitations to a National Conference with authorities and officers of museums, art galleries, and libraries which have been open in the United Kingdom on Sundays. The Conference has been called specially for the purpose of directing the attention of Parliament to the results which have attended the Sunday opening of museums, art galleries, and libraries in the United Kingdom, and it is expected that representatives will be present from each of these institutions. The Conference will assemble at St. James's Hall, on Wednesday, March 25, at half past two, and the proceedings will commence at three o'clock precisely.

AT the meeting of the Society of Arts on Wednesday, the 25th inst., Mr. A. J. Ellis will read a paper on the "Musical Scales of Various Nations." The paper will be illustrated by playing the scales, and occasionally strains on properly tuned instruments, and will form a continuation of the paper on the "History of Musical Pitch," read by Mr. Ellis before the Society in 1880. It is the result mainly of an examination of native instruments and performers, by which the exact pitch of the notes used was determined by Mr. Ellis and Mr. Hipkins, and will exhibit the scales in use in ancient Greece, in Arabia, India, Java, China, Japan, and other countries. The chair will be taken by Sir Frederick Abel, the Chairman of Council of the Society.

THE Committee of the Saltpetre Producers' Association, on the west coast of South America (Comité Salitrero at Iquique, Chili) offers 1000*l*. in prizes for essays on the use of nitrate of soda as manure. Of this amount (1) a prize of 500*l*. will be awarded for the best popular essay showing the importance of nitrate of soda as a manure, and the best mode of its employment. The essay, in its theoretical part, is to treat of the effect of nitrate of soda on vegetation, as compared with other manures containing nitrogen, and should exhibit the present state of knowledge on this point. In its practical part the essay is to give directions for the use of nitrate of soda in the various conditions of plant-culture. References and quotations, and purely scientific explanations, if necessary, are to appear as notes. The essay may be written in English, German (Italic character), or French. The writing must be distinct, and on one side of the paper only. It is desired that the length of the essay may not exceed six sheets of printed octavo. Each manuscript is to be signed with a motto; the name and address of the author is to be given in a sealed envelope bearing the motto outside. The essays are to be sent on or before October 1, 1885, to any of the undermentioned judges. (2) A prize of 500*l*. will be awarded for the best essay treating of the same subjects on the basis of new experimental researches, made by the author himself. The essays must fulfill the conditions already mentioned. They may be sent to any of the judges on or before January 1, 1887. The Committee of judges consists of the following agricultural chemists:—Germany: Prof. Paul Wagner, Director of the Agricultural Station at Darmstadt. England: Mr. R. Warington, Agricultural Laboratory, Rothamsted, St. Albans, Herts. United States of America: vacant. France: Prof. L. Grandeau, Director of the Agricultural Station, and Dean of the Faculty of Natural Philosophy at Nancy. Belgium: Prof. Petermann, Director of the Royal Agricultural Station at Gembloux. Holland: Prof. Adolf Meyer, Director of the Agricultural Station of the State at Wageningen. Russia: Prof. L. Thoms, Director of the Agricultural Station at the Polytechnical Institution at Riga. If none of the essays received should thoroughly satisfy the committee of judges, they are authorised to award inferior prizes of not less than 150*l*. each. Any essay for which a prize is awarded becomes the absolute property of the Saltpetre Producers' Association at Iquique, which also reserves to itself the right of translation into other languages.

IN his series of lectures on electricity, M. Becquerel *fils* exhibited at the Conservatoire des Arts et Métiers a loud speaking telephone, which was heard without difficulty throughout the amphitheatre. This will be one of the attractions of the forthcoming electrical exhibition at the Observatoire. The halls will be lighted by a new lamp constructed by MM. Breguet and Co.

THE January number of the *Melbourne Review* contains a very interesting article on the climatic vicissitudes of Victoria, by Mr. G. S. Griffiths. Referring to the researches of Baron von Müller, the writer says that that learned botanist has discovered striking testimony to the occurrence of rapid climatic changes in Australia. First he found that during the older Pliocene period the Australian flora was lauraceous—plants of the warmth-loving laurel family predominating. In the newer Pliocene deposits these laurels have been swept away, and are replaced by a meliaceous flora and by plants of a still more tropical character. Once more an active vegetation disappears, and in its stead the myrtle family, with its characteristic eucalypts, overspreads the whole land, and still keeps possession. What great climatic vicissitudes (Mr. Griffiths asks) could rob a region of a whole suit of vegetation and repeat the act twice within a brief period? He thinks this evidence to be strongly corroborative of the occurrence of interglacial periods. There

are, however, other facts. The pepper plant (*Drimys antartica*) is a native of the colder regions of the globe. When the Glacial epoch set in and a chilly temperature advanced to the equator itself, this plant marched forward with it in the same regions. When the interglacial warm period came on the cold temperature relaxed; but wherever the pepper plant had access to lofty mountains it retreated to their cold peaks, and so secured itself permanently in its new home. Then it died out on the hot plains, and thus Mr. Griffiths explains its existence upon the lofty ranges of New Guinea and Borneo, but nowhere else until we get far down into the colder regions of the southern hemisphere—its natural habitat. In the same manner cold-loving European plants crossed the hot tropics, unknown ages since, but probably at the same epoch, and established themselves in Australia; and so, when botanists in exploring the Australian mountains climbed to an altitude of 5000 feet, they met thirty-eight species of European plants, isolated from their fellows, and thousands of leagues from their home.

THE Russian Government has ordered from a Paris balloon factory two elongated silk balloons, in order to experiment on their direction by electricity. The Italian Government has also ordered two silk balloons equipped with telephones, &c., for captive ascents.

To the *Astronomische Nachrichten*, Nos. 2651–52, Herr von Gothard contributes an elaborate paper on the periodicity of the changes observed in the spectrum of β Lyræ during the year 1884. The observations of the previous year had already determined changes in the intensity of the bright bands, which could not be accounted for by mere atmospheric influences. Since then thirty fresh observations have enabled the author to follow through successive periods the shiftings of the bands D_3 from an almost brilliant intensity to their total disappearance. He was prevented by the unfavourable atmospheric conditions from determining the duration of the several periods, which however seemed to average not more than seven days. The hydrogen lines and also very probably those of the red, although more constant, also seem subject to periodical change. The spectroscopic phenomenon is of such a remarkable and unique character that observers are urged to direct their attention to this highly interesting star, with a view to a more accurate determination of its periodicity. Appended to the paper is a brief summary of the thirty observations taken at intervals from February 18 to November 17 of last year. Of these the following may be quoted as bearing on the short duration of the periodic changes:—July 13, D_3 of almost dazzling brightness; July 17, D_3 very faint; September 17, D_3 scarcely perceptible; September 24, D_3 again brilliant; November 1, D_3 invisible; November 5, D_3 bright.

AN important point in connection with recent seismic investigation in Japan which does not yet appear to have been noticed in this country, is the various intensities of the same shock and of different shocks at different places. One place appears more subject to earthquakes than another place which may be near at hand, and to be more violently affected than the latter by an earthquake which visits both. Thus, with similar instruments placed at the corners of a triangle having sides about 800 feet long, Prof. Milne has obtained conclusive evidence that, while at one corner there might be sufficient motion to shatter a building, at the other corners the disturbance would be trivial. In the last severe shock by which the capital of Japan was visited, the chimneys of the British Legation were shaken so severely that they had to be rebuilt, but the Russian Legation, a building of much the same character a mile away, suffered no appreciable damage. If in further investigation it turns out that certain portions of the same earthquake district are comparatively free from violent shocks, while the force of the earthquakes are concentrated in certain others, then seismic surveys would appear an indispensable pre-requisite of building in earthquake countries. A residence in "a desirable situation" would in that case mean, not one commanding a good view, or close to the station, church, and post-office, or convenient for a pack of hounds, but one built on an oasis unsympathetic to earthquakes, and which remains still and secure while its neighbours are being tossed about and destroyed by seismic forces.

THE Sixth Circular of Information of the United States Bureau of Education for 1884, compiled by Miss Annie T. Smith, a Member of the Office, is a digest of the information gained there on the subject of rural schools. It is hardly necessary to refer here to the difficulty of a thinly populated country like America—viz. the smallness of the schools, and hence, in defiance of State laws, the smallness of teachers' pay and teachers' qualifications. High authorities are here cited as to the ease with which much valuable information might be imparted to many such teachers who sorely need it. Good technical rules accordingly for teachers in any country, and a list of about eighty books bearing upon education and desirable for a schoolmaster's library are here given. The Circular records the eager desire for new ideas on the subject of elementary instruction manifest in all countries; and after quoting the highest English and American authorities on the subject, it gives a *résumé* of some recent publications of the Belgian and French Governments. The principal result of it all is to insist upon the great value of general object-lessons; for which purpose, moreover, French schools are cited as being provided with specimens of the materials used in the trades of the neighbourhood: to urge the teaching of geography first from the nearest surrounding view, and *then* from the map which has thus been made intelligible; of elementary arithmetic also by objects. The way in which, in agricultural di tricts, this object-learning goes on side by side with book-learning, especially in the cases of the youngest boys whose time is divided between school and labour, makes it a familiar phrase in America that "our brightest boys come from the country."

IN the report of the Temple Observatory at Rugby for 1884, Mr. Seabroke, the Honorary Curator, reports that the original work done during the past year consisted of the measurement of positions and distances of double stars, in continuation of that of former years. 264 complete measures of 108 stars were taken. The observations of double stars of the last four years have, it is stated, been presented to the Royal Astronomical Society, and ordered to be printed in the *Memoirs*. They number about 900 complete measures. A new list of stars for measurement in coming years has been prepared by Mr. Seabroke, with the assistance of Mr. C. H. Hodges. Some few measurements have also been made of the motion of stars in the line of sight with the spectroscope on the reflector.

THE decreasing tendency of the lobster fishery in America is becoming so marked that the United States Fisheries Commission is instituting inquiries into the causes operating against it. It is intended to investigate all points connected with the natural history of the species, the condition of the fishery grounds, &c., in order to arrive at a satisfactory conclusion on the subject.

THE Council of the National Fish Culture Association have decided to form an ichthyological library containing works of every description on the subject of our fish and fisheries, their culture and development.

WE have received separate reprints of the following papers read before the Chemical Society:—"On Additive and Con-

densation Compounds of Diketones with Ketones," by Messrs. Japp and Miller, and "On Condensation of Benzil with Ethyl Alcohol," by Dr. Japp and Miss Mary E. Owens.

WE have received from Messrs. Lancaster and Son, of Birmingham, a catalogue of photographic apparatus for dry-plate photography, and a useful illustrated pamphlet, "How to be a Successful Amateur Photographer," by W. J. Lancaster, F.C.S.

THE additions to the Zoological Society's Gardens during the past week include a Bonnet Monkey (*Macacus sinicus* ♀) from India, presented by Mrs. Thomas; a Grey Ichneumon (*Herpestes griseus*) from India, a Vulpine Phalanger (*Phalangista vulpina* ♂) from Australia, presented by Mr. J. G. Baxter; a Plantain Squirrel (*Sciurus plantani*) from India, presented by Lieut. A. H. Oliver, R.N.; a Barn Owl (*Strix flammea*), British, presented by Mr. W. P. Clark; a Red-billed Whistling Duck (*Dendrocygna autumnalis*) from South America, presented by Mr. Wm. Boutcher; an Indian Crocodile (*Crocodilus palustris*) from India, presented by Mr. John Murphy; a Common Boa (*Boa constrictor*) from South America, presented by Mr. Allen; an Algerian Tortoise (*Testudo mauritanica*) from North Africa, deposited; a Red-eared Monkey (*Cercopithecus erythrotis* ♂), a Pluto Monkey (*Cercopithecus pluto* ♀), a White-thighed Colobus (*Colobus vellerosus* ♂) from West Africa, a Hairy-nosed Wombat (*Phascolomys latifrons* ♀), a Blood-stained Cockatoo (*Cacatua sanguinea*) from South Australia, purchased; three Long-fronted Gerbilles (*Gerbillus longifrons*), born in the Gardens.

OUR ASTRONOMICAL COLUMN

TEMPEL'S COMET (1867 II.).—M. Raoul Gautier has circulated an ephemeris of this comet, intending to communicate the details of his calculation of the effect of the perturbations of Jupiter during the comet's long continuance in the neighbourhood of the planet in the last revolution to the *Astronomische Nachrichten*. The ensuing perihelion passage is retarded thereby rather more than 148 days: the major-axis of the orbit is considerably increased and the eccentricity diminished. As a consequence the perihelion distance receives a very important augmentation. This result, which could not have been foreseen without at least an approximate determination of the perturbations occasioned by the attraction of Jupiter, materially diminishes the chances of observing the comet during the present year, and indeed in future years, so long as the elements do not undergo considerable change. M. Gautier finds that the perihelion passage is delayed until September 25, but that the nearest approach of the comet to the earth occurs on March 31, when its distance is 1·51. The maximum theoretical intensity of light which is attained on April 10 is only 0·074 (if expressed in the usual manner); for comparison with this value, it may be remarked that on August 21, when Schmidt last observed the comet for position in that year, perceiving it, as he says, only "blickweise," the intensity of light was 0·21, and at M. Tempel's last observation at Florence on July 8, 1879, it was 0·33. It will therefore be obvious that the observation of the comet in the present year is at least doubtful, but an extract from M. Gautier's ephemeris, applying to the next period of absence of moonlight, is subjoined:—

At Berlin Midnight

	R.A.	Decl.	Log. distance from Earth	Log. distance from Sun
	h. m. s.	° ′		
April 2	11 55 17	+18 56·3	0·1792	0·3877
4	11 53 44	18 58·2		
6	11 52 14	18 59·1	0·1803	0·3851
8	11 50 47	18 58·9		
10	11 49 24	18 57·7	0·1824	0·3826
12	11 48 5	18 55·3		
14	11 46 52	18 51·8	0·1855	0·3801
16	11 45 43	18 47·2		
18	11 44 40	+18 41·6	0·1894	0·3776

The elements of the orbit are as follows (M. Eq. 1885·0):—

Perihelion passage, 1885, September 25·7649 M.T. at Berlin.

	°	′	″
Longitude of perihelion	241	26	1·0
,, ascending node	72	28	7·7
Inclination	10	50	27·2
Angle of excentricity	23	53	57·0
Log. semi-axis major	0·542244		
Mean daily sidereal motion	545″·3073		

The perihelion distance in 1867, in which year the comet was first detected by M. Tempel, was 1·564, the earth's mean distance from the sun being taken as unity: the above elements show that at perihelion passage in 1885, this distance will have been increased by perturbation to 2·073. The nearest approach of the comet to the earth's orbit occurs at or very close to perihelion, and it will appear that under the most favourable conditions, with the orbit of 1885, the theoretical intensity of light cannot exceed one-sixth of the value which it might have attained in the orbit of 1867. At aphelion in the new orbit the comet approaches that of Jupiter within 0·17.

THE VARIABLE STAR MIRA CETI.—Mr. Knott, who has had this star under close observation at Cuckfield since January 7, has ascertained that a maximum of 2·9 m. occurred on February 11, which is fourteen days later than given by the formula of sines in Prof. Schönfeld's second catalogue. The next minimum may be expected to fall about the middle of September, and the following maximum in the first days of January, 1886, assuming that there is a similar retardation on the date assigned by the formula.

ASTRONOMICAL PHENOMENA FOR THE WEEK, 1885, MARCH 22–28

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on March 22

Sun rises, 6h. 0m.; souths, 12h. 6m. 53·8s.; sets, 18h. 15m.; decl. on meridian, 0° 49′ N.: Sidereal Time at Sunset, 6h. 16m.

Moon (at First Quarter on March 23) rises, 9h. 22m.; souths, 17h. 12m.; sets, 1h. 5m.*; decl. on meridian, 17° 55′ N.

Planet	Rises	Souths	Sets	Decl. on meridian
	h. m.	h. m.	h. m.	° ′
Mercury	6 15	12 40	19 4	4 5 N.
Venus	5 50	11 28	17 6	4 57 S.
Mars	5 51	11 38	17 25	3 23 S.
Jupiter	14 42	21 57	5 12*	13 38 N.
Saturn	9 3	17 8	1 13*	21 47 N.

* Indicates that the setting is that of the following day.

Occultations of Stars by the Moon

March	Star	Mag.	Disap.	Reap.	Corresponding angles from vertex to right for inverted image
			h. m.	h. m.	° °
22	111 Tauri	5½	18 52	19 54	84 334
22	117 Tauri	6	21 2	21 23	56 19
24	68 Geminorum	5½	23 39	0 37†	122 294
26	B.A.C. 2872	6	0 41	1 38	113 295
27	*h* Leonis	6	1 45	2 36	82 319
27	B.A.C. 3529	6	22 24	23 23	37 303
27	43 Leonis	6	23 37	0 28†	131 233
28	B.A.C. 3836	6	22 19	23 19	24 290

† Occurs on the following day.

Phenomena of Jupiter's Satellites

March	h. m.		March	h. m.	
22	3 39	II. occ. disap.	25	4 11	IV. ecl. disap.
	20 17	I. tr. egr.		21 16	II. ecl. reap.
23	21 46	II. tr. ing.	27	3 58	I. occ. disap.
24	0 41	II. tr. egr.	28	1 18	I. tr. ing.
	18 43	III. ecl. reap.		1 50	III. tr. ing.
	20 49	IV. occ. disap.		3 37	I. tr. egr.
25	1 29	IV. occ. reap.		22 25	I. occ. disap.

The Occultations of Stars and Phenomena of Jupiter's Satellites are such as are visible at Greenwich.

March	h.	
22	16	Saturn in conjunction with and 3° 56′ north of the Moon.

March	h.	
27 ...	15 ...	Jupiter in conjunction with and 4° 40′ north of the Moon.
28 ...	3 ...	Venus in conjunction with and 0° 36′ south of Mars.
28 ...	9 ...	Mercury at least distance from the Sun.

GEOGRAPHICAL NOTES

DR. R. VON LENDENFELD, in a letter to Prof. Cayley dated Sydney, January 24, 1885, writes as follows:—I have been sent by the Geological Survey Department of this colony to make a scientific investigation of the central part of the Australian Alps and have returned a few days ago. I found out that the peak, considered as the highest hitherto, which has been measured by several scientists and named Mount Kosciusko, is *not the highest*, and made the first ascent of the highest peak some distance further south. I calculated the height of the latter at 7256 feet (Mount Kosciusko has been measured at 7176, 7175, and, by myself, at 7171 feet). I name this hill after our celebrated geologist, the Rev. W. B. Clarke, Mount Clarke. Further, I discovered indubitable signs of prehistoric glaciers above 5800 feet, and photographed some beautiful *roches moutonnées*. A large valley was filled at the glacial period by a glacier extending 500 feet up its sides. I had excellent weather, and photographed the panorama from the summit of Mount Kosciusko. I had one guide and a geological assistant with me. We camped only three nights, and had glorious weather all the time. The upper limit of trees lies at a height of 5900 feet. Patches of snow are found attached to the leeside of the main range above 6500 feet all the year round—in the European Alps such little *névés* would not lie below 8000 feet—another proof for the lower temperature and greater amount of wet south of the equator, as our Alps lie 46°–48° N., and Mount Kosciusko 37° S. I collected many flowers and geological specimens, and found the whole trip equally enjoyable and interesting. It froze every night, and I cannot tell you how happy and comfortable I felt in the brisk cold air up there, after having been confined to the hothouse climate of Sydney for a year.

THE Vienna correspondent of the *Times* telegraphs that at a private meeting of the committee of the Imperial Geographical Society of Vienna, it has been resolved that Dr. Oscar Lenz, Secretary of the Society, should be sent on a new expedition to explore the watershed between the Nile and the Congo. This expedition has been planned chiefly by Baron Leopold Hofmann, late Imperial Finance Minister, and now President of the Austrian African Association. Dr. Lenz will visit the stations of the International Belgian Society, and one of the objects of his journey will be to find traces of Dr. Junker, Dr. Schnitzler (known in Egypt as Emin Bey), Signor Cassati, and Lupton Bey. Dr. Lenz's journey will be under the special patronage of the Crown Prince of Austria and the King of the Belgians, and the cost will be defrayed partly by the Geographical Society of Vienna, partly by the Government and from private subscriptions. Dr. Lenz proposes to start early in May.

AT the meeting of the Geographical Society of Paris, held on the 6th inst., M. Mascart in the chair, Prince Roland Bonaparte referred to the recent exploration of the Van Braam Morics in New Guinea.—A correspondent of the Society wrote from Ciudad Bolivarin Venezuela that it was reported there that one of the members of the Crévaux mission was still living in captivity among a tribe of Indians, and it is also stated that fragments of a paper were found in a Bolivian forest, on which were written in letters of blood the name of the prisoner and his fate.—M. Teisserenc de Bort described the oasis of Djerid in Tunis. It contains 9,700 inhabitants.—A communication was read with reference to the tribes employed in the recent revolt in Morocco, correcting the names given to them.—M. Schrader read a paper on the masses of snow moved about by the wind amongst mountains. These masses are not carried about by chance—they obey very simple laws, which cause them to be deposited at spots where the wind is diminished in intensity, and give them forms which may easily be analysed when we take into account the quality of the snow, the force and direction of the wind, and the contour of the mountains.—M. Rabot described the results of the mission with which he was charged by the Minister of Public Instruction to explore Northern Finland and Russian Lapland. He explored especially the valleys of the Pasvig and Talom, as well as Lake Enara. The whole region is one immense forest, with lakes and peat-bogs scattered everywhere, and cut up by numerous water-courses. These rivers are the only means of communication, but their navigation is most difficult, on account of cascades and rapids. Lake Enara, which is drained by the Pasvig, is described by M. Rabot as a veritable inland sea, with hundreds of islets covered with magnificent pine trees. The climate is very rigorous. Winter begins in September, and the ice is still in the ground in the beginning of June. The spring is short, but comparatively warm, and it is not rare to see the frost again in August. The country around Lake Enara is level and little broken, and forms a depression between the plateau of Finmark and the masses of hills which stud Russian Lapland.

A WORK which will shortly be published by Prince Roland Bonaparte deals with the populations of Dutch Guiana from an anthropological and sociological point of view. He has studied three groups of the population: (1) the Indians (Caribs); (2) wild Negroes, or Negroes of the woods, being fugitive slaves who have returned to savage life; (3) freed slaves or settled Negroes. The section on the Negroes who have returned to their original state is probably the most interesting of the three. Many of these are descendants of slaves who fled from ill-treatment in the early days of the colony to the woods and inaccessible solitudes of the highlands. In 1712, when Admiral Cassard laid siege to Paramaribo, the planters sent away their slaves into the interior, so that they should not fall into the invader's hands, and they refused to return after the peace. Gradually their number augmented, and these Negroes formed themselves into villages and cultivated land. They grew so powerful that after several bloody and expensive wars, the Colonial Government found it expedient to make a treaty of peace, recognising them as allies, in 1762. At the present moment they number 8000 souls, and are divided into four sections or tribes, according to the locality in which they have settled. They appear to have preserved most of the characteristics of the Negro, but they have adopted many of the habits and modes of life of the Indians, by whom they are surrounded.

THE first number of the *Scottish Geographical Magazine*, the organ of the new Scottish Geographical Society, has been issued. It aims at being much more than the organ of the Society, however. It begins with Mr. Stanley's opening address, and a somewhat perfervid article on Scotland and geographical work. This is followed by a most instructive article by Prof. James Geikie on the physical features of Scotland, accompanied by a map essentially new in design and nomenclature. The geographical notes occupy about fourteen pages, and are unusually full and comprehensive, aiming at a nearly exhaustive chronicle of geographical progress in all departments. This is followed by a *résumé* of geographical literature for 1884, new books and new maps. Besides Prof. Geikie's map there is one of the river basins of Africa, and a portrait of Mr. Stanley. Altogether the *Magazine* is a valuable addition to the literature of its class, creditable to the enterprise of the Society and the knowledge and intelligence of its editors.

ACCIDENTAL EXPLOSIONS PRODUCED BY NON-EXPLOSIVE LIQUIDS[1]

TEN years ago the lecturer discussed in some detail the various causes of the continually recurring casualties which are classed under the head of accidental explosions, and he then had occasion to compare the causes of coal-gas explosions, the occurrence of which is as deplorably frequent now as it was then, with those of accidents connected with the transport, storage, and use of volatile inflammable liquids which are receiving extensive application, chiefly as solvents and as illuminating agents.

Within the last few years he has had occasion to devote special attention to the investigation of instances of this class of accident, and to examine more particularly into the probable causes of frequent casualties connected with the employment of lamps in which the various products included under the general designations of petroleum and paraffin oil are burned. The latter branch of these inquiries, which is still in progress, has been conducted in association with Mr. Boverton Redwood, the talented Secretary and Chemist of the Petroleum Association, and with the valuable aid of Dr. W. Kellner, Assistant-Chemist

[1] Address delivered at the Royal Institution of Great Britain, Friday, March 13, 1885, by Sir Frederick Abel, C.B., D.C.L., F.R.S., M.R.I.

of the War Department. Although it may be hoped that their continuation will lead to further data and conclusions of practical and public importance, it is thought that some account of facts already elicited may interest the members of the Royal Institution, and possess some general value.

Ever since liquids which, more or less rapidly, involve inflammable vapour when freely exposed to air, or partially confined, have been in extensive use, casualties have occurred from time to time through the accidental or thoughtless ignition of the mixtures of vapour and air thus formed, whereby more or less violent and destructive explosions have been produced, often followed by the ignition of the exposed liquid which is the source of the explosive mixture, and by the consequent frequent development of disastrous conflagrations.

Many instances are on record of explosions, sufficiently violent to produce effects destructive or injurious to life and property, resulting from the application of flame to vessels which had contained either the more volatile coal-tar- or petroleum-products, or strong spirituous liquids, and which, though they had been entirely or nearly emptied of their contents, still contained, or retained by absorption within their body, some of the volatile liquid, this having, by evaporation into the air in the emptied receptacle, produced with it a more or less violently explosive mixture. Thus, a loud explosion occurred at the entrance of a lamp-maker's shop in Whitecross Street, which was found to have been caused by a boy throwing a piece of lighted paper into a cask standing under the gateway, which had contained benzoline; two boys were very seriously injured by the blast of flame which was projected from the barrel. A perfectly analogous accident was soon afterwards reported in the papers as having occurred at Sheffield, with serious injury to the author of the catastrophe and another boy; and a very similar case occurred at Exeter during the removal of some empty benzoline barrels, consequent upon a boy applying a lighted match to the hole of one of them. Again, at Spaxton in Somersetshire, a young man applied a light to the hole of a benzoline cask, described as nearly empty, which was standing in the road, when three young men were blown across the road, one of them being so seriously injured about the head that he died.

Explosions with similarly disastrous results have also been publicly recorded as having resulted from the application of a light to rum puncheons and whisky casks, even some time after they have been emptied of their contents, the evaporation of the alcohol absorbed by the wood having sufficed to convert the confined air into a violent explosive mixture.

The readiness or extent to which inflammable vapour is evolved from those products of the distillation of petroleum, or of shale or coal, which are used for illuminating purposes, differs of course considerably with the character of these liquids. Those which are classed as petroleum spirit (known as gasoline, benzine, benzoline, naphtha, japanners' spirit, &c.), and in regard to which there exist very special precautionary enactments, are, it need scarcely be said, of far more dangerous character than those classed as burning oils, which include the paraffin oils obtained from shale and the so-called flashing points of which range from 73° to above 140° Fahrenheit. The rapidity with which the vapours, evolved by the more volatile products on exposure to air, or by their leakage from casks or barrels, diffuse themselves through the air, producing with it more or less violent explosive mixtures, has been a fruitful source of disaster, sometimes of great magnitude. The lecturer had occasion to refer, in his discourse of 1875, to an accident at the Royal College of Chemistry of which he was a witness, in 1847, when the lamented Mr. C. B. Mansfield was engaged in the conversion of a quantity of benzol into nitrobenzol in a capacious glass vessel, which suddenly cracked, allowing the warm liquid hydrocarbon to escape and flow over a large surface. This occurred in an apartment 38 feet long, about 30 feet wide, and 10 feet high; there was a gas jet burning at the extremity of the room opposite to that where the heated liquid was spilled, and within a very brief space of time after the vessel broke, a sheet of flame flashed from the gas jet along the upper part of the room, to the spot where the fluid lay scattered.

The origin of a fire which occurred at some mineral oil stores at Exeter in 1882 affords another striking illustration of the great rapidity with which the vapour of petroleum spirit will diffuse itself through the air. The store which caught fire, and which contained both petroleum oil and spirit, or benzoline, was one of a range of arched caves upon the bank of a canal, being separated from it by a roadway about 50 feet wide. It was a standing rule at the stores that no light should be taken to any one containing benzoline. The casks which contained this liquid were to be removed, and the foreman, desirous of beginning this work early, and forgetful of the rule, went to the store shortly before daylight, carrying a lighted lantern, which he placed upon the ground at a distance of several feet from the door. He then proceeded to open these. As he did so, he noticed a very powerful odour of benzoline, and, almost immediately, he saw a flash of flame proceed from the lantern to the store. He had just turned to escape, when an explosion occurred which blew the doors and the lantern across the canal; the benzoline in the store was at once inflamed, and flowed out into the road and upon the surface of the water, firing a small vessel which lay against the quay, and setting fire to the stores of benzoline contained in two neighbouring caves.

Many exemplifications might be cited of the danger arising from the accidental spilling or escape of petroleum spirit (or even of oils of very low flashing point) in the ordinary course of dealing with these liquids, as in stores where there is but very imperfect ventilation, and in some part of which a flame exists, or is carelessly introduced; or from the escape of spirit or its vapour from stores or receptacles to adjacent spaces where, its existence being unsuspected, the ignition of the resulting explosive mixture of vapour and air may be at any time brought about.

Without referring to accidents which have been due to flagrant carelessness in introducing a flame or striking a light in a store where petroleum vapour is likely to exist in the air, or where some form of spirit has been accidentally spilled, a few instances may be quoted which illustrate the magnitude of casualties liable to arise from the causes just referred to. Some years ago an explosion productive of much damage occurred in a sewer at Greenwich, and was clearly traced to the entrance into the sewer of some petroleum products (from a neighbouring patent gas factory); the vapours from these had diffused themselves through the air in the sewer to a considerable distance, forming with it an explosive mixture which must have been accidentally ignited at one of the sewer openings in the street above. Last spring a similar accident occurred at Newport in Monmouthshire, a quantity of benzoline having escaped into a sewer from a neighbouring store; the ignition of the resulting explosive mixture of vapour and air, with which a considerable length of the sewer became filled, tore up the roadway to some distance, several persons being thrown down. A terrific disaster of the same class was reported from San Francisco in November, 1879. During the driving of a tunnel in the San José Santa Cruz Railway, a vein of petroleum became exposed by the excavators, who were, of course, working with naked lights. Three violent explosions occurred in consequence, in rapid succession, resulting in the death of twenty-five Chinamen and in the injury of seventeen others and two white men.

Another accident, which occurred near Coventry nearly five years ago, may be quoted in illustration of the unsuspected manner in which explosive gas-mixtures may exist in localities which, to the superficial observer, may appear to have no connection with a neighbouring locality where volatile liquids are liable to escape confinement.

A dealer in benzoline spirit kept his small store of that liquid (from 20 to 80 gallons) in an apartment of his house, upon the basement, the floor of the room being paved with red bricks. At a distance of about three feet from the store-room there was a well, the depth of which to the surface of the water was twenty feet. The well was closed in almost entirely with planks covered with earth. The water in the well being found foul, the owner had the latter uncovered, with a view to its being cleared out. The workman in charge of the operation, after having been engaged for three hours in pumping out a large quantity of the water, lowered a lighted candle into the well, according to the usual practice, to see whether he could descend with safety, when, while bending over the opening, he perceived a blue flame shooting upwards, and was violently thrown back and badly burnt, a woman who was watching him being similarly injured. The benzoline which had been spilled from time to time in small quantities in filling the cans of customers had readily passed through the porous brick upon which it fell, and, gradually permeating the soil beneath, had, in course of time, drained into the adjacent well. That this must occur under the circumstances described would have been self-evident to any one acquainted with the behaviour of these liquids and with th

attendant circumstances. In localities where large quantities have for some time been stored in the usual casks or barrels, there is no difficulty in "striking oil" by sinking a well in the immediately adjacent ground, in consequence of the large amount of leakage of the spirit or oil which must unavoidably occur. Even in the absence of leakage from the openings of the barrels, or from any accidental imperfection, considerable diffusion of the volatile liquid, and consequent escape by evaporation through the wood itself, must occur in large petroleum-stores, especially if much exposed to the sun, and in the holds of ships where the temperature is generally more or less high. Even the precaution adopted of rinsing the barrels before use with a stiff solution of glue is not effectual in preventing the escape of the spirit from these causes, as the effect of alternations of temperature upon the barrels must tend to reopen any unsound places temporarily closed by the glue. Even at very extensive depôts, where special arrangements were adopted to maintain the stores uniformly at a very moderate average temperature, the loss of petroleum spirit from leakage and evaporation was estimated, ten years ago, to amount to about 18 per cent. of the total stored, while the average loss from the same causes upon petroleum oil was about 9 per cent. By the introduction, from time to time, of improvements of the arrangements, the loss of spirit by leakage and evaporation has been very considerably reduced, amounting to less than 8 per cent. in well-constructed stores, while at some petroleum stores, more especially in Germany, the loss of oil from leakage is now said not to exceed 1 per cent.

As in the case of the loss of coal-laden ships by explosions on the high seas, such loss has probably, in many cases, been due to the development of gas from the cargo, and to its diffusion into the air of parts of the ship more or less distant from the coal, producing an explosive atmosphere which might become ignited by the conveyance or existence of a light or fire, where its presence was not deemed dangerous; so also it is not improbable that the supposed loss by effects of weather of missing petroleum-laden vessels may have occasionally arisen from fire, caused in the first instance by the diffusion of vapour escaping from the cargo through the air in contiguous parts of the ship, and the accidental ignition of the explosive atmosphere thus produced.

The possibility of such disasters has been demonstrated by the repeated occurrence of accidents of this class in ports or their vicinity. A very alarming instance of the kind occurred in 1871 on the Thames off Erith. Two brigantines had nearly completed the discharge of their cargoes of petroleum spirit ("naphtha"), when another vessel, the *Ruth*, from Nova Scotia, containing upwards of 2000 barrels of the same material, together with other inflammable cargo, anchored alongside them. This ship had encountered very severe weather, and it had been necessary to batten down the hatches; the cargo in the hold had consequently become enveloped in the vapour which had escaped from the casks. On the removal of the hatches, an explosive mixture was speedily produced by access of air, and, through some unexplained cause, became ignited shortly after the vessel anchored. A violent explosion followed, and the vessel was almost instantly in flames, the fire being rapidly communicated to the other two ships, which were with difficulty saved, after sustaining considerable injury, while the *Ruth*, in which the fire raged uncontrollably, was after a time towed to a spot where she could burn herself out and sink without damage to the other shipping. Three of the crew were seriously injured by the explosion, and the mate was blown to some distance into the water.

In June, 1873, a vessel (the *Maria Lee*), laden with 300 barrels of petroleum and other inflammable cargo, was destroyed by fire on the Thames near the Purfleet powder magazines, consequent upon the explosion in her of a mixture of petroleum-vapour and air; and a similar accident occurred about the same time in Glasgow harbour. In the case of the *Maria Lee* it was clearly proved that the vapour resulting from leakage and evaporation of the spirit in the hold had diffused itself through the ship during the night, which was very hot, the hatches having been kept closed and covered with tarpaulin, in consequence of the occurrence of a thunderstorm. Upon the captain entering his cabin in the after part of the ship early in the morning (and probably striking a light) a loud explosion took place, and flame was immediately seen issuing from the fore-part of the ship.

A very similar casualty to the foregoing occurred at Liverpool four years afterwards, in a small vessel laden with petroleum-spirit, which proved not to have been at all adapted by internal construction for the safe carriage of such a freight. The cargo of 214 barrels of spirit had been stowed on board, and the hatches were put down and covered with tarpaulin. The cabin and forecastle of the smack were below deck, and were only separated by a thin partition from the hold. The loading had been completed between six and seven o'clock in the evening, and at about eight o'clock the captain went into the cabin and kindled a lamp. A man upon deck, who with another was injured by the explosion and fire, saw the light burning in the forecastle, and almost immediately afterwards the deck was lifted and the man was thrown some distance, while flame issued from the hold. The captain was terribly burned, and died shortly afterwards. In vessels which are constructed for the American petroleum trade, the cabins and forecastles are all upon deck, that part of the vessel which carries the freight, between decks, being as completely as possible separated from the other parts of the ship.

In some instances, ships laden with petroleum oil have become inflamed, in an unexplained manner, without the occurrence of any noticeable explosion, as was the case last year with a large vessel (the *Aurora*) in the port of Calcutta, after she had discharged more than half her cargo of 59,000 cases. The vessel burned for nine hours, the river becoming covered with burning oil as she gradually filled with water; the direction of the wind and the condition of the tide at the time of her sinking fortunately prevented the fire from reaching the shipping higher up the river.

There is no doubt that, while with cargoes of the more volatile petroleum products, classed as spirit, the greatest precautions are necessary to guard against the possible ignition of more or less explosive mixtures of vapour and air which will be formed in the stowage spaces of ships, and which may extend to other parts of the vessels unless very efficient ventilation be maintained, ships laden with the oils produced for use in ordinary petroleum or paraffin lamps, and which, yielding vapours at temperatures above the standard fixed as a guarantee of safety, incur comparatively very little risk of accident, provided simple precautions be observed. If, moreover, by some act of carelessness, or some accident not guarded against by the prescribed precautions, a part of such cargo does become ignited, the prompt and, as far as practicable, complete exclusion of air from the seat of fire, by the secure battening down of the hatches, will most probably save the ship from destruction. There are numerous records of vessels having discharged cargoes of petroleum oil, many barrels of which have been found greatly charred on the outside, occasionally even to such an extent that the receptacle has scarcely sufficient strength remaining to retain its contents. A remarkable illustration of the controllable nature of a fire in a petroleum-laden ship was furnished by the ship *Joseph Fish*, laden with refined petroleum, lubricating oil, and turpentine, which, a fortnight after leaving New York (in September, 1879), was struck by lightning during a heavy squall, the hatches being closed at the time. Smoke at once issued from below, and the force-pumps were set to work directly to keep the fire down. The hatches were removed for examination as the fire appeared to gain ground, but were immediately replaced, and, after further pumping, as the fire appeared to increase, and an explosion was feared, the crew took to their boats, remaining near the ship. Eight hours afterwards they were picked up by a passing ship, which remained near the *Joseph Fish* until daylight. Her captain then returned on board, and as he found that the fire appeared to be out, the crew returned and the ship resumed her voyage, reaching the port of London without further incident, except that, during the use of the pumps for removing the water, considerable quantities of petroleum and turpentine were pumped up with it from the hold. When the cargo was discharged, a large number of the barrels bore evidence of the great heat to which they had been exposed; several casks had gone to pieces, and the staves of others were charred quite half-way through, although they still retained their contents.

The lecturer had occasion, ten years ago, to dwell upon the recklessness with which fearful risks were incurred, in some cases no doubt ignorantly, but in others scarcely without a knowledge, on the part of those who were responsible, of the nature of the materials dealt with, by transporting volatile and highly inflammable liquids together with explosive substances in barges or other craft, and in doing so, moreover, without the adoption of even the most obvious precautions for guarding against access

of fire to the contents of those vessels. The instance of the explosion, in 1864, of the *Lottie Sleigh* at Liverpool, laden with $11\frac{1}{2}$ tons of gunpowder, in consequence of the accidental spilling and ignition of some paraffin oil in the cabin of the ship, illustrated the danger incurred in permitting these materials to be together on board a vessel, and should have furnished some warning by the publicity it received; but the explosion, ten years later, on the Regent's Park canal, of the barge *Tilbury*, revealed the continued prevalence of the same reckless disregard of all dictates of common prudence in dealing with the joint transport of explosives and volatile inflammable liquids.

The efficient laws and Government inspection to which all traffic in explosives has since then been subject, have rendered the recurrence of that identical kind of catastrophe almost out of the question, but an illustration has not been wanting quite recently of the fact that, but for the respect commanded by the rigour of the law, barges passing through towns would probably still carry freights composed of petroleum spirit and powder or other explosives, being at the same time provided with a stove, lamp, and matches for the convenient production of explosions. In August, 1883, an explosion occurred on the canal at Bath, in a barge which sank immediately, the master being slightly injured; the freight of the vessel consisted of petroleum, benzoline, and lucifer-matches.

The last four years have furnished several very remarkable illustrations of great injuries inflicted on ships by explosions, the origin of which was traced to the existence on board of only small quantities of some preparation containing petroleum spirit, or benzoline, with the nature of which the men who had charge of them were not properly acquainted. These materials had, consequently, been so dealt with as to become the means of filling more or less confined spaces in the ships with an explosive atmosphere which, when some portion of it reached a flame, was fired throughout, with violently destructive effects.

The first authenticated case of an accident due to this cause occurred in June, 1880, on board the Pacific Steam Navigation Company's steamer *Coquimbo*, shortly after her arrival in the morning at Valparaiso from Coquimbo. A violent explosion took place, without any warning or apparent cause, in the forepeak of the vessel, blowing out several plates of the bow and doing other structural damage, besides killing the ship's carpenter; the explosion could only be accounted for by the circumstance that a small quantity of a benzoline preparation used for painting purposes (probably as "driers") was stored in the fore-peak and that a mixture of the vapour from this with the air had become ignited. The sufferer was the only person who could have thrown light upon the precise cause of the accident, but there was no other material whatever in that part of the ship to which the explosion could have been in any way ascribed.

In May, 1881, an explosion of a trifling character occurred on board H.M.S. *Cockatrice* in Sheerness Dockyard, in consequence of a man going into the store-room with a naked light and holding it close to a small can which was uncorked at the time, and which contained a preparation recently introduced into the naval service as a "driers" for use with paint, under the name of *Xerotine Siccative*. This preparation, which was of foreign origin, appears to have been adopted for use in the naval service and to have been issued to H.M.'s ships generally without any knowledge of its composition and without attention being directed to the fact that it consisted very largely of the most volatile petroleum spirit, which would evaporate freely if the liquid were exposed to air at ordinary temperatures, and the escape of which from a can, jar, or cask, placed in some confined and non-ventilated space, must speedily diffuse itself through the air, and render the latter more or less violently explosive.

When attention was directed to the highly inflammable character of this xerotine siccative by the slight accident referred to, official instructions were issued by the Admiralty, in June, 1881, to ships and dockyards that the preparation should be stored and treated with the same precautions as turpentine and other highly inflammable liquids or preparations.

The following November, however, telegraphic news was received of a very serious explosion on board H.M.S. *Triumph*, then stationed at Coquimbo, due to the xerotine siccative. The explosion took place early in the evening of November 23, and originated in one of the paint-rooms of the ship; the painter, and a marine who was assisting him, were in the upper paint-room at the time; the former received severe internal injuries and afterwards died, the latter was killed at once. One man standing at the open door of the sick bay furthest from the explosion was instantaneously killed, others in close proximity receiving only superficial injuries. Altogether there were two killed, two dangerously wounded—of whom one died—and six injured by the explosion.

The results of the official inquiry held at Callao led to the conclusion that the explosion was caused by the ignition of an explosive gas-mixture produced by xerotine siccative which had leaked from a tin kept in a compartment under the paint-room and quite at the bottom of the ship, usually termed the "glory hole;" that locality having been considered by the captain of the ship as the safest place in which to keep this material, to the dangerous nature of which his attention had been recently called by the receipt of the Admiralty Circular. It transpired that the painter had sent his assistant down to this compartment from the paint-room to fetch some paint. The man, who had a hand-lantern with him, while opening the hatch, which had not been opened for three days, made a remark that there was a horrible smell; the chief painter told him to return, as he thought the smell was due to foul air, and immediately afterwards the explosion occurred.

The tin can which had contained six gallons of the liquid was found, after the accident, to have received injury as though some heavy body had fallen, or been placed, upon it; this appeared to have been done before the explosion, and there is no doubt that the liquid had leaked out of the can, and had evaporated into the air in the compartment beneath the paint-room, and probably also to some extent in the adjoining spaces. The damage done was very considerable. An iron ladder leading from one paint-room to the other was so twisted up as to have lost all semblance of originality, the wooden bulkhead separating the upper paint-room and sick bay was completely blown away, the framing of the ship's side in the sick bay was blown inwards and broken, the furniture in the latter was completely shattered, and the bedding and clothes of the men near the explosion were much burned. The inquiries which followed upon this deplorable accident showed that, while due precautions were taken to store the supplies of mineral oil used for burning purposes, of turpentine and of spirit, which were sent to different naval stations for supply to the fleet, in special parts of the ship or on deck, this highly inflammable liquid, which was far more dangerous than other stores of this class, had been sent in freight-ships as common cargo, being stored in the hold without any precautions. A stone jar which was advised as containing a supply had arrived at its destination in the Pacific quite empty, the contents having leaked out and evaporated on the passage out, so that the vessel carrying it had been unsuspectedly exposed to very great danger.

(To be continued.)

PROGRAMME OF WORK TO BE PURSUED AT THE U.S. NAVAL OBSERVATORY AT WASHINGTON, D.C., DURING THE YEAR BEGINNING JANUARY 1, 1885[1]

The Great Equatorial

1. OBSERVATIONS of a selected list of double stars will be continued. These stars are such as have rapid orbital motions, or which present some other interesting peculiarity.

2. Conjunctions of the inner satellites of Saturn during the opposition of the planet will be observed. There will also be made a complete micrometrical measurement of the dimensions of the ring.

3. There will be made three drawings of Saturn—one before opposition; one at or near opposition; and one after opposition.

4. The observations which have been begun for stellar parallax, and for the temperature coefficient of the screw of the micrometer, will be finished.

The Transit Circle

1. Observations of the sun will be made whenever the necessary ephemeris stars can be observed, and the required instrumental corrections determined.

2. The moon will be observed through the whole lunation.

3. The major planets will be observed from fifteen to twenty times, near opposition.

[1] Transmitted by Commodore S. R. Franklin, U.S.N., Superintendent.

4. Each minor planet will be observed at least five times, near opposition, when practicable.

5. Observations of the list of miscellaneous stars will be finished as soon as practicable.

THE TRANSIT INSTRUMENT

1. Observations will be made as often as practicable for time, for the correction of the standard meantime clock; and computations will be made daily for such correction.

2. Observations for the right ascensions of the sun, moon, and inner planets to be made as frequently as possible; observations of the major planets, and of the brighter of the minor planets, to be made near opposition.

3. The observations made during 1883 will be prepared for publication; and the computations of those of 1884 continued.

THE 9·6-INCH EQUATORIAL

Observations will be made:—

1. Of all the minor planets whose brightness at opposition is greater than their mean brightness.

2. Of comets, to determine position and physical peculiarities.

3. Of occultations of stars by the moon.

4. When arrangements shall have been made to photograph the sun, any sun-spots which show any decided peculiarities in the photographs will be examined with the spectroscope.

THE PRIME VERTICAL TRANSIT INSTRUMENT

Observations of a selected list of stars in conjunction with the Royal Observatory at Lisbon, in pursuance of the plan recommended by the International Geodetic Association, for the determination of variability of latitude.

TIME-SERVICE AND CHRONOMETERS

The time-balls at Washington and New York will be dropped daily at noon of the 75th meridian; and the noon signals will be extended to such other places throughout the country as may be desirable, as rapidly as arrangements may be made.

The rating of chronometers will be continued as heretofore.

Meteorological observations will be made as usual.

THE MURAL CIRCLE

Observations will be made of stars down to the 7th magnitude south of ten degrees North declination, the positions of which have not been recently determined at some northern observatory; the observing list to be formed of all stars from Gould's Uranometria Argentina visible here, and not found in Yarnall's Catalogue, the Transit Circle list of B.A.C. stars, or the recent Catalogue of the Glasgow Observatory.

SCIENTIFIC SERIALS

Rendiconti del Reale Istituto Lombardo, January 29.—On a special class of involutions of space known as monoidal, by Dr. V. Martinetti.—Analysis of the meteorological observations made at the Brera Observatory, Milan, during the year 1884, by E. Pini.—An experimental study of the thermic phenomena accompanying the formation of alloys, by Prof. Domenico Mazzotto.—On some eruptive rocks occurring between Lakes Maggiore and Orta, by Prof. Giuseppe Mercalli.—On the geometrical movement of invariable systems, by Prof. C. Formenti.—International right in connection with the proposed Italian penal code, by Prof. A. Buccellati.—Meteorological observations taken at the Brera Observatory during the month of January.

February 12.—On the psychological act of *attention* in the animal series, by E. T. Vignoli.—On S. Grimaldi's project of an agrarian credit as a remedy for existing evils among the agricultural classes in Italy, by P. Manfredi.—On a class of configurations of the third power, by Prof. G. Jung.—On the geometrical movement of invariable systems, by Prof. C. Formenti.—On an integer more general than that of living forces for the movement of a system of material points, by Dr. G. Pennacchietti.—Integration of the differential equation $\Delta^2 u = 0$ in some very simple planes, by Prof. G. Ascoli.

Sitzungsberichte der Naturwissenschaftlichen Gesellschaft Isis, Dresden, 1884.—The organs of smell in the articulated animals, by Dr. Kraepelin.—An account of the Papuan inhabitants of Aru, Eastern Archipelago, communicated in a private letter to H. Engelhardt.—On *Anguillula radicicola*, a parasite infesting the coffee-plant on the Brazilian plantations, by B. Frank.—Phytological observations made on the flora of Dresden during the years 1883 and 1884, by A. Wobst.—On the morphology of the orchids, by Dr. O. Drude.—On the diluvial fauna of the Prohlis district, by Dr. Geinitz.—Remarks on some rare crystals of zircon and pyrites from Cornwall and Ontario, Canada, by A. Purgold.—On some archæological objects from Saxony, the Harz, and Italy, apparently connected with superstitious practices, by H. Wiechel.—On the chemical constitution of the colouring substance known as methylic blue, by Dr. R. Möhlau.—Memoir on new and little-known bird's eggs and nests from the Eastern Archipelago, specimens of which are possessed by the Dresden Zoological Museum, by A. B. Meyer.—On the latest geological researches in North America, by Dr. H. B. Geinitz. Remarks on the crepuscular phenomena observed in Europe and elsewhere at the end of the year 1883 and beginning of 1884, by Prof. G. A. Neubert.

Rivista Scientifico-Industriale, January 31.—Influence of static electricity on lightning conductors (concluded), by Prof. Eugenio Canestrini.—On the Westinghouse compressed air continuous brake, by the Editor.—Improved method of preserving ornithological specimens, by Dante Roster.

SOCIETIES AND ACADEMIES

LONDON

Royal Society, March 5.—"On the Atomic Weight of Glucinum (Beryllium)." Second Paper. By T. S. Humpidge, Ph.D., B.Sc., Professor of Chemistry in the University College of Wales, Aberystwyth. Communicated by Prof. E. Frankland, F.R.S.

This paper is a continuation of one previously communicated to the Royal Society (*Proc. Roy. Soc.*, vol. xxxv. p. 137). The author has prepared a sample of metallic glucinum, having the composition—

Gl	99·20
GlO	0·70
Fe	0·20
	100·00

and has determined its specific heat at varying temperatures up to 450° with the following results (for pure glucinum):—

c^{11}_{100}	0·4286
c^{13}_{145}	0·4515
c^{11}_{193}	0·4696
c^{15}_{240}	0·4885
c^{14}_{312}	0·5105
c^{11}_{360}	0·5199
c^{17}_{447}	0·5403

These results correspond to the following empirical formula for the true specific heat of the metal at varying temperatures—

$$k_t = k_0 + 2\alpha t + 3\beta t^2,$$

or with numerical values—

$$k_t = 0{\cdot}3756 + 0{\cdot}00106t - 0{\cdot}00000114t^2,$$

whence the following values for k_t are calculated:—

k_0	0·3756
k_{100}	0·4702
k_{200}	0·5420
k_{300}	0·5910
k_{400}	0·6172
k_{500}	0·6206

If these values are graphically represented the curve so obtained reaches a maximum at about 470°, and then falls; but whether it represents the specific heat at higher temperatures than 500° is doubtful. The specific heat of glucinum thus rises rapidly up to about 400°, and remains approximately constant between 400° and 500° at 0·62. If this number is multiplied by 9·1 it gives the atomic heat 5·64. Glucinum, therefore, belongs to the same class as carbon, boron, and silicon, which agree with Dulong and Petit's rule at high temperatures only. And the true atomic weight is that required by the periodic law—viz. 9·1 and not 13·6, as was previously deduced from the specific heat between 10° and 100°.

This conclusion is confirmed by the author's determinations of the vapour-densities of glucinum chloride and bromide in a platinum vessel. The experiments were done in an atmosphere of carbonic acid collected over mercury after Meier and Crafts (*Berlin. Ber.*, xiii. 851), and gave the following results:—

I. *Glucinum Chloride*

	Substance	Displaced CO_2	t	d
Experiment i.	26·4 mgrms.	7·47 c.c.	635°	2·733
,, ii.	28·0 ,,	7·98 ,,	785°	2·714

The theoretical density of $Gl''Cl_2$ is 2·76, and this formula, therefore, represents the molecule of this compound.

II. *Glucinum Bromide*

	Substance	Displaced CO_2	t	d
Experiment ii.	35·9 mgrms.	4·28 c.c.	608°	6·487
,, iii.	61·1 ,,	7·53 ,,	630°	6·276
,, iv.	26·0 ,,	3·22 ,,	606°	6·245

The density of $Gl''Br_2$ is 5·84, and that of $Gl'''Br_3$ is 8·76. The agreement in this case is not so close as in the case of the chloride, but is sufficiently near to show that the true molecular formula is $Gl''Br_2$, and not $Gl'''Br_3$. Thus, the vapour-density of both compounds necessitates the atomic weight 9·1. The result is a striking argument in favour of the value of deductions drawn from the periodic law in regard to the atomic weight of an element, and shows that such deductions will in future form one of the most important factors in fixing a doubtful atomic weight. The author did not appreciate the full value of the periodic law when he wrote his former paper, otherwise he would probably have stated his conclusions less positively.

Zoological Society, March 3.—Prof. W. H. Flower, F.R.S., President, in the chair.—Dr. E. Hamilton made some remarks on the supposed existence of the Wild Cat (*Felix catus*) in Ireland, as stated at a former meeting, observing that there was no record of the Wild Cat being indigenous to that country. Dr. Hamilton believed that the cat shown at the meeting in question was only the offspring of domestic cats born and bred in the woods of that district.—A letter was read from Mr. J. H. Thomson, C.M.Z.S., giving the locality of *Helix* (*Hemitrochus*) *filicosta*, which had been previously unknown.—Dr. A. Günther, F.R.S., exhibited and made remarks on the skin of a singular variety of the Leopard which had been obtained in South Africa. The back in this specimen was black, and the tail reddish gray, while the usual characteristic spots of the ordinary leopard were nearly altogether absent.—Mr. H. H. Johnston, F.Z.S., gave a general account of the principal animals observed by him during his recent journey to Kilimanjaro and his stay on that mountain.—Mr. Oldfield Thomas read a report on the Mammals obtained and observed by Mr. Johnston during his expedition.—Capt. G. E. Shelley read a report on the birds collected by Mr. H. H. Johnston in the Kilimanjaro district. The collection contained examples of fifty species, six of which were believed to be new to science.—Mr. Charles O. Waterhouse read a paper on the insects collected on Kilimanjaro by Mr. H. H. Johnston, and gave the descriptions of six new species of Coleoptera, of which examples occurred in the collection.—Prof. F. Jeffrey Bell read a description of a Nematoid Worm (*Gordius vermcosus*) obtained by Mr. Johnston on Kilimanjaro, which was found to be parasitic on a species of *Mantis*.—Mr. E. J. Miers communicated the description of a new variety of River-Crab of the genus *Thelphusa* (*T. depressa*, Krauss, var. *Johnstoni*), which had been obtained by Mr. H. H. Johnston in the streams of Kilimanjaro.—Mr. Francis Day read the fourth of the series of his papers on races and hybrids among the Salmonidæ, continuing the account of the Howietown experiments from November, 1884, to the present time.—Prof. Ray Lankester read some notes on the heart described by Sir Richard Owen in 1841 as that of *Apteryx*, and came to the conclusion that the heart in question was that of an *Ornithorhynchus*.

Chemical Society, February 19.—Dr. W. H. Perkin, F.R.S., President, in the chair.—The President announced that Mr. Warren de la Rue, F.R.S., had presented a bust of the late Prof. Dumas. The following papers were read:—On benzoylacetic acid and some of its derivatives, part 2, by Dr. W. H. Perkin, jun.—On toughened filter-paper, by E. E. H. Francis.—The detection and estimation of iodine, by Ernest H. Cook, B.Sc. (Lond.).—Note on methylene chlor-iodide, by Prof. J. Sakurai.—A quick method for the estimation of phosphoric acid in fertilisers, by J. S. Wells, Columbia College.—On the luminosity of methane, by Lewis T. Wright, Assoc.M.Inst.C.E.—On the oxides of nitrogen, by Prof. W. Ramsay and J. Tudor Cundall. In this research it is shown—(1) That the green or blue liquid obtained by the action of arsenious anhydride on nitric acid consists of a mixture of nitrous anhydride and nitric peroxide, in proportions depending on the strength of the nitric acid and the temperature at which the volatile liquid is condensed. (2) That if a dehydrating agent, such as sulphuric acid, be present in sufficient quantity the distillate consists of pure peroxide, and that this process is by far the most convenient one for the preparation of the peroxide. (3) That if oxygen be passed over the blue liquid, the vapours condensed in a freezing mixture are still blue or green; a great excess of oxygen is necessary to effect conversion from nitrous anhydride into peroxide. (4) That when excess of nitric oxide is passed along with the peroxide into a cooled bulb, the trioxide is produced, the amount of trioxide depending on the temperature of the condenser. (5) Vapour-density of a liquid of a deep blue colour, containing about 30 per cent. of trioxide and 70 per cent. of peroxide, shows that the trioxide cannot exist in the gaseous state, but at once dissociates into nitric oxide and peroxide on changing to gas. The theoretical vapour-density of such a mixture was calculated from a formula deduced from the second law of thermodynamics by I. Willard Gibbs, which shows the relations between temperature, pressure, and vapour-density of the mixture of NO_2 and N_2O_4 in the gaseous peroxide; and it was found that the vapour-densities of a mixture of $(NO_2 + N_2O_4)$ (partly present in the original liquid as peroxide, partly formed by the decomposition of the N_2O_3 present into NO and $(NO_2 + N_2O_4)$) with the NO produced by the decomposition of the N_2O_3, calculated by means of Gibbs' formula, are identical, within limits of experimental error, with those obtained by direct experiment. (6) The presence or absence of moisture does not appear to affect the reaction between NO and O_2. (7) It is probable that N_2O_3 undergoes dissociation with rise of temperature, even while liquid.—Discussion:—Dr. Armstrong said that he had listened to the paper with great interest, as he had made numerous experiments on the subject, and had long been of opinion that N_2O_3 did not exist, at all events as gas. The authors' observations, whereby they were led to this conclusion, were of considerable importance, and it was to be hoped that ere long confirmatory evidence that would more directly appeal to chemists would be forthcoming. It was noteworthy that there was no recorded evidence proving the existence of N_2O_3 as gas. Gay-Lussac's experiments, published in 1816, showed that nitric oxide and oxygen only reacted in the proportions to form N_2O_4, and that reactions in proportions corresponding with the production of N_2O_3 only took place in presence of alkali. The method adopted by the authors did not suffice to prove the existence of N_2O_3, even as liquid, and the results could be equally well interpreted on the assumption that they were dealing with a solution of NO in N_2O_4. It was to be expected that N_2O_4 would be a good solvent of NO, as it appeared to be the rule that bodies which are related are easily miscible, phosphorus, for example, being very soluble in PCl_3, and sulphur in CS_2 and S_2Cl_2. One observation made by the authors did, however, support their view, viz. the observation that the blue liquid was with great difficulty oxidised by passing oxygen into it. In all his experiments, Dr. Armstrong had found that the reactions attributed to N_2O_3 could be equally well affected by a mixture of N_2O_4 and NO. As to the action of arsenious oxide on nitric acid, in his opinion, ***nitrous acid*** was ***the*** product, and the manner in which this underwent change entirely depended on the conditions. In dilute solution, NO would be produced in accordance with the equation: $3HNO_2 = 2NO + HNO_3 + H_2O$; but in presence of nitric acid the reaction $HNO_2 + HNO_3 = N_2O_4 + H_2O$ would take place, and would more and more preponderate the less the amount of water present. The addition of sulphuric acid would of necessity favour the latter mode of change. When N_2O_4 is passed into sulphuric acid, nitrosyl sulphate and nitric acid are formed; in presence of NO the latter is reduced to nitrous acid which also forms nitrosyl sulphate with the sulphuric acid, so that a mixture of NO and N_2O_4 in proper proportions precisely acts as though it were N_2O_3.

Anthropological Institute, March 10.—Francis Galton, F.R.S., President, in the chair.—The election of G. F. Legg was announced.—Mr. James G. Frazer read a paper on certain burial customs as illustrative of the primitive theory of the soul. The Romans had a custom that when a man who had been reported to have died abroad returned home alive, he should enter his house, not by the door, but over the roof. This custom (which is still observed in Persia) owed its origin to certain primitive beliefs and customs with regard to the dead. The ghost of an unburied man was supposed to haunt and molest the

living, especially his relatives. Hence the importance attached to the burial of the dead; and various precautions were taken that the ghost should not return. When the body of a dead man could not be found, he was buried in effigy, and this fictitious burial was held to be sufficient to lay the wandering ghost, for it is a principle of primitive thought that what is done to the effigy of a man is done to the man himself.—The director read a paper by Admirel F. S. Tremlett, on the sculptured dolmens of the Morbihan. About eighty sculptures had been found, invariably on the interior surfaces of the cap-stones and their supports. It is remarkable that they are confined within a distancc of about twelve miles, and are all situated near the sea-coast, beyond which, although the megaliths are numerous, there is a complete absence of sculptures. The sculptures vary in intricacy from simple wave-lines and cup-markings to some that have been compared to the tattooing of the New Zealanders.

Geological Society, February 25.—Prof. T. G. Bonney, F.R.S., President, in the chair.—Bennett Hooper Brough, Parvati Nath Datta, Robert Stansfield Herries, William Herbert Herries, Rev. Edward Jordon, Lees Knowles, and William Hobbs Shrubsole were elected Fellows of the Society.—The following communications were read:—On a dredged skull of *Ovibos moschatus*, by Prof. W. Boyd-Dawkins, F.R.S.—On fulgurite from Mont Blanc, by Frank Rutley, F.G.S.—On brecciated porfido-rosso-antico, by Frank Rutley, F.G.S.—Fossil Chilostomatous Bryozoa from Aldinga and the River Murray Cliffs, South Australia, by Arthur Wm. Waters, F.G.S. The seventy three fossils described in the present paper were collected by Prof. Ralph Tate, and, with a few exceptions, are from Aldinga and the River Murray Cliffs, Australia. This collection again furnishes interesting cases of species growing in both the Eschara and the Lepralia form; but the chief interest is in a number of specimens which grow in a "cupulata" manner, thus in the mode of growth resembling *Lunulites*. Attention was again called to the fact that, though the shape and nature of the zoœcial avicularia (onychocellaria) are characters of the greatest value, yet their presence or absence cannot be made a specific distinction, as there are a large number of cases where specimens are found with none or only a few such avicularia, whereas on other specimens of the same species, collected under similar circumstances, they may occur abundantly over the whole colony, or in parts of the colony, in large numbers. In the *Challenger* Report, Mr. Busk refers to a slender process rising from the middle of the base of the avicularian mandible, and names it "columella." This he considers only occurs in one division of the *Celleporæ*, and in this division only in those belonging to the southern hemisphere. This was shown to be by no means the case, as it is found in the mandibles of *Cellepora sardonica* from the Mediterranean, in two other common Mediterranean *Celleporæ*, &c. In many species there is a denticle in this position rising from the calcareous bar which divides the avicularium. This denticle occurs in various genera and species, and may often be found a useful specific character when examining fossils. Out of the 220 species now described in this series of papers, just about one-half are now known living. The species noticed in this paper are seventy-three in number, referred by the author to the genera *Cellaria, Membranipora, Micropora, Monoporella, Steganoporella, Cribrilina Mucronella, Microporella, Lunulites, Porina, Lepralia, Smittia Schizoporella, Mastigophora, Retepora, Rhynchopora, Cellepora, Lekythopora*, and *Selenaria*. Five species are described as new, namely, *Microporella pocilliformis, Lepralia confinita, Cellepora biradiata, Schizoporella protensa*, and *Membranipora temporaria*.

Victoria Institute, March 16.—Mr. W. P. James read a paper on the relation of fossil botany to theories of evolution, in which he gave a *résumé* of the whole question with which his paper dealt.

EDINBURGH

Mathematical Society, March 13.—Mr. George Thom, Vice-President, in the chair.—Mr. George A. Gibson read a paper on Gilbert's method of treating tangents to confocal conicoids.—Mr. J. S. Mackay gave an account of Schooten's geometry of the rule.—Mr. A. Y. Fraser read a note by Mr. P. Alexander on two definite integrals.

PARIS

Academy of Sciences, March 9.—M. Bouley, President, in the chair.—Obituary notices of the late M. J. A. Serret, Member of the Section for Geometry, by MM. Jordan, Bonnet, Faye, and Renan.—Methods of observing the polar stars at a great distance from the meridian, with a table containing the corrective term intended to facilitate the reductions, by M. M. Lœwy.—Bromuretted substitutions of the polyatomic phenols, by MM. Berthelot and Werner. Here the authors deal with resorcine ($C_{12}H_6O_4$) and orcine ($C_{14}H_8O_4$) diatomic phenols, each of which furnishes a tribromuretted substance capable of being employed in their quantitative analysis.—On the decomposing action exercised by the chloride of aluminium on certain hydrocarburets, by MM. C. Friedel and J. M. Crafts.—Report on the new gallery of palæontology in the Paris Natural History Museum, by M. A. Gaudry. This gallery, which has been fitted up in the Whale Court, contains specimens of *Megatherium Cuvieri, Elephas meridionalis, Mastodon augustidens, Cervus megaceros, Testudo elephantina, Pelagosaurus typus, Palæotherium magnum*, and some other gigantic extinct animals.—Observations of the planet 245, discovered by M. Borrelly at the Observatory of Marseilles, by M. Stephan.—On some anomalies in the phenomenon of tides in connection with M. Hatt's work, by M. de Jonquières.—Report on the International Congress of Washington, and on the resolutions there adopted respecting the first meridian, the universal hour, and the extension of the decimal system to the measurement of angles and of time, by M. J. Janssen, representative of France at the Congress. The report, which is partly occupied with M. Janssen's address objecting to Greenwich, and advocating a neutral first meridian at the Azores or Behring's Straits, concludes with the words: "However this be, and apart from the question of the meridian, which is not yet decided, let us not forget that the accession of England to the convention for the metrical system and the wish expressed for its general extension are important results, showing that our presence in Washington has not been useless either for science or progress."—Report on M. Léauté's memoir on oscillations at long intervals in machines propelled by hydraulic action, and on the means of preventing those oscillations, by M. Phillips.—Observations of Encke's comet made at the Observatory of Paris (equatorial coudé), by M. Périgaud.—Spectroscopic studies, by M. Ch. V. Zeuger. The author submits a method for clearing from the field of vision all rays except those lying nearest to the C band, and for thus observing, by means of the parallelopiped of dispersion, the protuberances proper to hydrogen under the monochromatic red light.—A method of avoiding the dangers incident to mechanical generators of electricity: reply to M. Daussin's claim to priority of invention, by M. A. d'Arsonval.—Study of the means employed to take the potential of the atmosphere: electromotor force of combustion, by M. H. Pellat.—On the decomposition of salts by water, by M. H. Le Chatelier. The author, against the generally-accepted views, formulates and demonstrates the two following propositions:—(1) The quantity of free acid required to resist the decomposition of a salt in solution increases indefinitely with the proportion of the salt contained in the fluid; (2) the decomposition of a salt in solution increases or diminishes with the changes of temperature, according as this decomposition absorbs or liberates heat.—On the separation of titanium from niobium and zirconium, by M. Eug. Demarçay.—On the normal pyrotartaric and succinic nitriles ($CN-(CH_2)-CN$; and $CN-(CH_2)_2-CN$), by M. Louis Henry.—On the preparation, properties, and reactions of iodacetone, by MM. P. de Clermont and P. Chautard.—Heat of formation of the glyonal bisulphide of ammoniac, by M. de Forcrand.—Researches on the colouring matters of leaves; identity of the orange-red matter with carotine, $C_{18}H_{24}O$, by M. Arnaud.—On the analogies with and differences between the genus Simœdosaurus of the Cernay fauna, Rheims district, and the genus Champsosaurus of Erguelinnes, by M. V. Lemoine.—Underground rumblings heard on August 26, 1883 (date of the Krakatoa eruption), at the island of Caiman-Brac, Caribbean Sea, 20° N. lat., 80° E. long., by M. F. A. Forel.—Remarks on the three first numbers of Rossi's decennial *Bulletin* of the Observatory and central geodynamic Archives of Rome, by M. Daubrée.

BERLIN

Physical Society, February 6.—Dr. König communicated an experiment he had carried out in conjunction with Dr. Richarz, with a view to testing the ground of a misgiving expressed at a recent meeting of the Society in connection with a plan he had set forth for the purpose of determining the constants of gravitation (*vide* NATURE, vol. xxxi. p. 260). It was maintained that the lead block of 2000 centners would, on

account of its weight, become extended at its base and consequently change its form—a circumstance which would prove very prejudicial to the experiments contemplated in connection with it. Dr. König and Dr. Richarz had, therefore, calculated the pressure exercised by the lead mass, which should have a basal plane of 1·9 square metres, on the square centimetre, and had found it equal to 2·3 kg. They then prepared a small lead cylinder, placed it with due underlayers on the earth, and by means of pulleys and weights caused a constant pressure of more than 6 kg. per square centimetre to be exerted on its smooth upper surface. Two fine steel spikes were fastened in the side of the lead mass, and their distance from each other exactly measured. After this pressure had been exerted for a considerable length of time on the lead, the distance of the two steel spikes from each other was again determined, and all the displacement which had occurred was found to be but 0·01 mm., an amount which might very well have been caused by differences of temperature. At all events it was so trifling, that in the case of a pressure three times less, such as would be that of the large lead mass utilised in the quantitative experiment, no deformation due to its own weight was to be apprehended.—Dr. König further reported on measurements of colour-sense and visual acuteness effected by him on a number of Zulus at present staying in Berlin. Their colour-sense was tested by means of the leucoscope. On the turning of the Nicol prism the savages stated distinctly that the colours of the two images became even more similar to each other, and at last almost alike, and that, on a further turning of the Nicol prism, the colours came to vary more and more from each other. The colour-sensibility of the savages was, therefore, equal to that of the normal eyes of civilised peoples. They distinguished with exactness, and denoted by different names the colours red, yellow, blue, brown, black, and white. While they distinguished as red only the purest spectral red, they denoted as yellow or as blue all objects having any yellowish, or, on the other hand, any bluish tinge. As "grass colours" they called the green, and violet they named after a mineral unknown to Dr. König. The unsaturated colours they defined by affixing a syllable to the name of the particular colour in each case, an affix signifying much the same as "young." The visual acuteness was measured by means of Snellen's writing tests, according to which the smallest characters used, when distinctly seen at a distance of 6·5 m., was equal to 1. From extensive statistical investigations in Germany the visual acuteness of a perfectly normal eye was found to average 1·75. The measurements taken with male Zulu adults showed, on the other hand, that they were able to recognise with certainty the smallest written characters at a distance of from 24 m. to 25 m.; a Zuly boy of about eight years showed a visual energy of only 1·50; and a Zulu woman a still lower value of visual force—a result which was, however, to be explained by the circumstance that the woman was squint-eyed, and had, moreover, clearly-ascertained obscurations of the cornea.—Following up this address, Dr. König intimated that, in the Physical Institute, experiments had been made by Dr. Uhthoff on the influence of light intensity on visual acuteness. From a large number of experiments it appeared that if the light intensity was taken as abscissa, and the degrees of visual acuteness appertaining to it as ordinates, then the resulting curve, in the case of the greatest visual acuteness answering to a good full illumination by day, ran parallel to the axis of the abscissa, falling, at first slowly and then rapidly, towards the null point. The mode of the sinking of the curve was different with different individuals. Under low light intensities differences occurred as much as 1 to 2. The visual energy became null shortly before the light intensity was null. In this respect likewise, however, there were differences in the case of different individuals, those possessing a greater acuteness of vision showing the visual energy at the null point under a greater light intensity than in the case of such persons as had a lower acuteness of vision, in whom the curve began nearer the null point of the abscissa. Normal eyes with greater acuteness of vision, under the highest light intensities attainable by means of a petroleum lamp, showed symptoms of dazzlement, and the curve sank to the axis of the abscissa. In the case of the eyes of much less visual acuteness the curve, even under these highest intensities, continued still parallel to the abscissa. In the discussion which this address gave rise to, Prof. von Helmholtz brought out and established, by entering into detail, that it was altogether unjustifiable to assume that the ancients had not such developed colour-sense as recent persons, and that this assumption was an inference quite unwarrantably drawn from the mere defect of names for the different colours.

February 20.—Dr. Kayser referred to a method published by M. Wolf in the *Comptes Rendus* for measuring the velocity of light, which differed from Foucault's experiment inasmuch as the rotating mirror was concave and the aperture admitting the light was a small transparent spot in a larger concave mirror. By Wolf's method the displacement of the reflection of the light could be made to reach as much as 1 m., and could be easily measured with precision.—Prof. Neesen made some communications respecting an investigation, which was not yet concluded, into Geissler's tubes. In an older tube with aluminium electrodes he found that the process of evacuation, up to the highest degree of rarefication, at which the electricity no longer passed through the tube, was rendered more difficult if continuous electric discharges were sent through the tube, but, on the other hand, was very easy when no electric current was transmitted. If, with high degrees of rarefication, phosphoric light filled the glass ball, a black precipitate was regularly formed on the glass, which disappeared on the admission of a small quantity of air into the tube. If the tube was put in communication with an electric lamp, and the carbon thread, after being kept in a glowing state for about an hour, was allowed to cool, a complete vacuum was more easily obtained, probably because the gaseous substances adhering to the glass were absorbed by the carbon. In such a case it was of no consequence for the evacuation whether a discharge was transmitted continuously through the tube or not. The phosphoric light, after the absorption by the carbon-thread, was likewise changed. Instead of being yellow and filling up the whole ball, it was rosy, limited, and soon disappeared. If the tube was then for some time exposed to the air and evacuated, yellow phosphoric light and the black precipitate again appeared. Prof. Neesen was of opinion that the process of phosphorescence was induced by substances which were absorbed by the glass and decomposed by the electric light, and that the black precipitate was a product of this decomposition.—Dr. Sklarck referred shortly to the measurement of the propagation velocity of electricity in telegraph wires, which Prof. Hagenbach, in Basel, had carried out according to a new method.

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